

A

0
0
0
7
3
4
7
2
7
1

UC SOUTHERN REGIONAL LIBRARY FACILITY

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

VINE PRUNING IN CALIFORNIA

By FREDERIC T. BIOLETTI



The native vine of California (*Vitis Californica*).

REVISION OF
BULLETINS Nos. 241 and 246
JUNE, 1921

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1921

DAVID P. BARROWS, President of the University.

EXPERIMENT STATION STAFF

HEADS OF DIVISIONS

THOMAS FORSYTH HUNT, Dean.

EDWARD J. WICKSON, Horticulture (Emeritus).

WALTER MULFORD, Forestry, Director of Resident Instruction.

CLARENCE M. HARING, Veterinary Science, Director Agricultural Experiment Station.

B. H. CROCHERON, Director of Agricultural Extension.

HUBERT E. VAN NORMAN, Vice-Director, Dairy Management.

JAMES T. BARRETT, Acting Director of Citrus Experiment Station, Plant Pathology.

WILLIAM A. SETCHELL, Botany.

MYER E. JAFFA, Nutrition.

RALPH E. SMITH, Plant Pathology.

JOHN W. GILMORE, Agronomy.

CHARLES F. SHAW, Soil Technology.

JOHN W. GREGG, Landscape Gardening and Floriculture.

FREDERIC T. BIOLETTI, Viticulture and Fruit Products.

WARREN T. CLARKE, Agricultural Extension.

JOHN S. BURD, Agricultural Chemistry.

CHARLES B. LIPMAN, Soil Chemistry and Bacteriology.

ERNEST B. BABCOCK, Genetics.

GORDON H. TRUE, Animal Husbandry.

FRITZ W. WOLL, Animal Nutrition.

W. P. KELLEY, Agricultural Chemistry.

H. J. QUAYLE, Entomology.

ELWOOD MEAD, Rural Institutions.

H. S. REED, Plant Physiology.

J. C. WHITTEN, Pomology.

*FRANK ADAMS, Irrigation Investigations.

C. L. ROADHOUSE, Dairy Industry.

R. L. ADAMS, Farm Management.

F. L. GRIFFIN, Agricultural Education.

JOHN E. DOUGHERTY, Poultry Husbandry.

W. B. HERMS, Entomology and Parasitology.

L. J. FLETCHER, Agricultural Engineering.

EDWIN C. VOORHIES, Assistant to the Dean.

DIVISION OF VITICULTURE AND FRUIT PRODUCTS

F. T. BIOLETTI

L. O. BONNET

W. V. CRUICK

G. BAROVETTO

A. W. CHRISTIE

* In coöperation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

CONTENTS

A. INTRODUCTION

	PAGE
Literature: Need of the Bulletin	5
Definition: Objects; Scope	5-6
Some Results of Defective Pruning	6

B. HABITS AND CHARACTERISTICS OF THE VINE

Vitis Vinifera: Structure of a Cultivated Vine	9
Pruning and Descriptive Terms	11
Roots; Trunk; Head; Branches; Arms; Spurs; Fruit Canes; Buds; Shoots; Water-sprouts; Suckers; Laterals; Fruit Wood; Sterile Wood.	

C. THE PRINCIPLES OF PRUNING

Physiological Principles	25
Winter Pruning	26
Season; Amount; Young and Old Vines; Units of Pruning.	
Summer Pruning	34
Weakening effect; Concentrating effect; Uses; Disbudding; Thinning of Shoots; Topping Young Vines; Suckering; Water-sprouting; Pinch- ing; Topping; Defoliating; Thinning the Fruit; Ringing; Cutting Surface Roots.	
Restriction and Treatment of Wounds	44
Supports: Staking, Trellising	47-50
Pruning Tools: Disposal of Prunings	51
Principles of Economy	53

D. THE PRACTICE OF PRUNING

Pruning Systems: Ideals of Pruning; Californian Systems	55
Periods of Development: Before Planting; Planting	64-68
First Season: First Winter Pruning; Staking	69-71
Second Season: Summer Pruning; Second Winter Pruning	72-74
Third Season: Summer Pruning; Third Winter Pruning	79-80
Pruning after the Third Winter	84
Fan-shaped Vines and Long Pruning; Double-headed Vines	89-91
Vertical Fruit Canes; Bowed Fruit Canes	93
Vertical Cordons: Single; Double; Multiple	95
Horizontal Cordons: Unilateral; Bilateral	97
Renovation of Imperfect and Misshapen Vines	103
Choice of System: List of Varieties for Long, Half-long, and Short Pruning	106

ILLUSTRATIONS

Cover Cut, Wild Vine of California (*Vitis Californica*).

- Fig. 1. Trunks of *V. Californica*.
- Fig. 2. Root crown of four-year-old vine.
- Fig. 3. Typical cultivated vine with short arms.
- Fig. 4. Typical cultivated vine with long arms.
- Fig. 5. Vine "eye," cross section.
- Fig. 6. Fruit bud, cross section.
- Fig. 7. Fruit bud, longitudinal section.
- Fig. 8. Sterile bud, longitudinal section.
- Fig. 9. Shoot showing position of blossom bunches.
- Fig. 10. Shoot showing laterals and second crop.
- Fig. 11. Unit of short pruning.
- Fig. 12. Unit of long pruning.
- Fig. 13. Tokay bunch before and after thinning.
- Fig. 14. Black Morocco bunch improved by thinning.
- Fig. 15. "Cinecturing" knife for ringing.
- Fig. 16. Fungous decay due to large pruning wounds.
- Fig. 17. Position of pruning shears.
- Fig. 18. Method of cutting the end of a spur.
- Fig. 19. Pruning tools.
- Fig. 20. Burning the "brush" after pruning.
- Fig. 21. Brush burner.
- Fig. 22. Forms of head pruning, spurs and half-long.
- Fig. 23. Forms of head pruning, long fruit canes.
- Fig. 24. Trellised vine with fan-shaped head and long fruit canes.
- Fig. 25. Single vertical cordon.
- Fig. 26. Unilateral horizontal cordon.
- Fig. 27. Forms of cutting.
- Fig. 28. Bundle of one-year rooted vines.
- Fig. 29. Rooted vine with single cane.
- Fig. 30. Rooted vine with two canes.
- Fig. 31. Rooted vine with canes at two levels.
- Fig. 32. Rooted vine pruned ready for planting.
- Fig. 33. Rooted vine with roots at different levels.
- Fig. 34. Result of planting too deep.
- Fig. 35. Root growth of a properly pruned and properly planted young vine.
- Fig. 36. Growth of vine during the first summer.
- Fig. 37. Vine at end of first growing season.
- Fig. 38. Growth and treatment during the second growing season.

- Fig. 39. Second winter pruning for head of medium height.
- Fig. 40. Second winter pruning for high head.
- Fig. 41. Second winter pruning of very vigorous vine.
- Fig. 42. Third spring, ready for disbudding.
- Fig. 43. Third spring, cane too short.
- Fig. 44. Vineyard during the third summer.
- Fig. 45. Crop at the end of the third season.
- Fig. 46. Three-year-old vine ready for pruning.
- Fig. 47. Three-year-old vine pruned.
- Fig. 48. Three-year-old vines pruned: A, for vase-formed; B, for fan-shaped head.
- Fig. 49. Four-year-old vine pruned for vase-formed head.
- Fig. 50. Four-year-old vine with high head.
- Fig. 51. Seven-year-old vine with fully developed vase-formed head.
- Fig. 52. Nine-year-old vine with fully developed vase-formed head pruned.
- Fig. 53. Fifteen-year-old vineyard.
- Fig. 54. Four-year-old fan-shaped vine before pruning.
- Fig. 55. Four-year-old fan-shaped vine after pruning.
- Fig. 56. Trellised vineyard of Sultanina defective.
- Fig. 57. Trellised Sultanina vine in full bearing.
- Fig. 58. Double-headed vine on trellis.
- Fig. 59. Vine with vertical canes.
- Fig. 60. Vineyard with vertical fruit canes defective.
- Fig. 61. Vertical cordon, young vine unpruned.
- Fig. 62. Vertical cordon, young vine pruned.
- Fig. 63. Vineyard of vertical cordons.
- Fig. 64. Vertical cordon, ultimate form unpruned.
- Fig. 65. Vertical cordon, ultimate form pruned.
- Fig. 66. Vertical cordon with double trunk.
- Fig. 67. Forming the cordon, second winter pruning.
- Fig. 68. Half-long pruning of horizontal cordons.
- Fig. 69. Horizontal cordon, unilateral, short pruned.
- Fig. 70. Horizontal cordon, unilateral, long pruned, defective.
- Fig. 71. Vineyard of horizontal cordons, unilateral, defective.
- Fig. 72. Vineyard of horizontal cordons, bilateral.
- Fig. 73. Young vine with imperfect top.
- Fig. 74. Pruning to renew imperfect top.

VINE PRUNING IN CALIFORNIA

BY FREDERIC T. BIOLETTI

PART I

INTRODUCTION

Literature.—A large number of books have been published on the pruning of the vine, but none of them are very well adapted to the needs of the Californian vine grower. Most publications in English refer to methods suited to the eastern states and to eastern varieties or to the conditions of hothouse cultivation. Foreign publications, besides being more or less inaccessible, refer to conditions different from those of the Pacific Slope or treat the subject so broadly that the grower is at a loss to choose from such a mass of material.

Need of the Bulletin.—The demand for information on vine pruning is large and the need for such information is made evident by the unsightly, defective, and unprofitable condition of many of our vineyards. This seems a suitable time for the publication of a new bulletin which will incorporate the experience of the older and more skillful grape growers and the results of the experiments and observations of the experiment station workers. The constant influx of new settlers, who are planting and growing vines with little knowledge of the methods which have proved best in California, and the opening up of new vine-growing districts make necessary some guide that will help to avoid the numerous mistakes made in the past.

Definition.—The term pruning, both by derivation and usage, is applied to various operations performed in cutting off certain portions of the vine. There are other operations, however, the purpose of which is similar or identical, which must logically and for convenience be discussed at the same time. Some of these are the removal of buds and shoots by other means than cutting, and the attachment of the vine or its parts to stakes, wires, or other supports. For this reason some writers call the subject the "pruning and training of the vine." The word "training," however, is misleading when applied to any of the vineyard operations used in California. It implies methods of shaping the vine which we do not use, and it does not properly describe the various operations of suckering, disbudding, water-sprouting, and the attachment of fruit canes which we do use. The word pruning, moreover, seems sufficient alone, as all the other operations follow and are necessitated by the methods of cutting or pruning-proper adopted.

Objects.—The main objects of pruning, in the wider sense, are first, to give the vine a suitable form and to conserve this form; and second,

to so regulate the bearing that the maximum quality and quantity of crop may be obtained for a long series of years at the minimum expense.

Scope.—The crop *possibilities* of a vineyard, both as regards quantity and quality, depend on many factors, of which the chief are the character of soil and climate, the amount of available water, and the nature of the variety of vine. What part of these possibilities is *realized* depends on the operations of the vineyardist—on how he handles the soil and the vine. One of the most important of these operations is pruning. By improper pruning we may neutralize the most favorable conditions and destroy the effect of the most careful cultivation. The skillful pruner, on the other hand, gives his vines the opportunity to utilize to the full all the natural and cultural advantages. Many vineyards produce less than half their proper average crop owing to mistakes in pruning, and there are few vineyards in the state where both the amount and the quality of the crop could not be increased considerably by improved methods of pruning.

There are two great difficulties in the way of reforming the pruning methods in most vineyards. One is the difficulty of obtaining pruners possessed of the necessary skill and knowledge. The other is the lack of the proper knowledge on the part of the owner of the vineyard. Of these difficulties, the latter is by far the more serious in its effects and its removal would in most cases obviate the greater part of the trouble resulting from the former.

Some Results of Defective Pruning.—In order to emphasize the necessity for proper pruning, it may be well to consider some of the results of defective pruning as shown below:

1. Deficient average annual amount of crop due to:
 - (a) Delay of bearing of young vines.
 - (b) Irregularity of development of vines.
 - (c) Failure to utilize properly full vigor of best vines.
 - (d) Lack of sufficient fruit buds.
2. Inferior quality due to:
 - (a) Overbearing of weak vines.
 - (b) Irregular distribution of the grapes and consequent irregular ripening.
 - (c) Injurious contact of grapes with soil, canes, and each other.
3. High cost of vineyard operations, such as:
 - (a) Cultivation, plowing, hoeing.
 - (b) Pruning, suckering.
 - (c) Control of diseases, oidium, vine-hopper.
 - (d) Gathering, trimming, sorting, culling.

4. Shorter life of vines due to:

- (a) Pruning and cultivation wounds.
- (b) Occasional overbearing.
- (c) Growth of suckers.

A young vine under average conditions in California should bear a paying crop at three years; that is, in the autumn of the third leaf or third summer in the field. At four years it should be practically in full bearing. Under exceptionally favorable conditions, bearing may be nearly a year earlier than this. In the cooler regions and with certain varieties, a year longer may be necessary. These results can be obtained only when the pruning during the first years is properly done.

Irregularity of development of individual vines is incompatible with the highest returns for the whole vineyard. Vines dwarfed by defective pruning can not compete with their more vigorous neighbors and will fail to produce a full crop. Full returns from a vineyard can be obtained only when there is comparative uniformity of vigor in the individual vines. This uniformity can be secured only by carefully adapting the pruning to each case. If vigorous and weak young vines are pruned alike, the former may bear nothing and increase their vigor while the latter may bear worthless grapes and increase their weakness.

When the vines reach the age of full bearing, the failure to adapt the pruning to the individual case is equally disastrous. A method of pruning adapted to a weak vine would prevent a vigorous vine from bearing and waste its possibilities, while a method adapted to a vigorous vine would cause a weak vine to attempt to bear a large crop of worthless grapes and perhaps die in the attempt.

Certain methods of pruning may result in an abnormally large crop one year, though usually at the cost of quality. Such a crop is always followed by a small one. Alternate bearing of this kind diminishes the average crop of a term of years. The neglected possibilities of one year can be utilized by the vine only in part during the following year.

Unless the pruner can distinguish the fruit buds he may fail to leave a sufficient number. The loss from this cause is the greater the more vigorous the vines, and greater with certain varieties than with others.

Bad pruning is a frequent cause of inferior quality. When the crop is too large for the vigor of the vine, or even of a part of the vine, the grapes will be small, will fail to develop sugar, flavor, or color and may dry up or sunburn before they are ripe. Bad pruning results

in uneven and improper distribution of the grapes on a vine. This is particularly harmful to shipping grapes, and results in uneven ripening and coloring. The grapes are subjected to different conditions of light and heat according to their distance from the ground and to the degree in which they are shaded by the leaves or other grapes.

On a vine of unsuitable form, the bunches may lie on the ground and be contaminated by the soil and subject to mildew and mold, or they may be entangled with each other or with the canes, making it impossible to harvest them without injury or loss.

Not only is the crop diminished and the quality injured by bad pruning but the cost of production is increased.

Vines of proper and uniform shape can be plowed, cultivated, and hoed with a minimum of labor. Such vines can be pruned and suckered at much less cost than irregular, misshapen vines. The control of the vine-hopper, of oidium, and of other diseases is more difficult unless the vines are of regular, standard shape.

The harvesting of the grapes, especially of shipping grapes, is much simpler and more satisfactory if the vines are well pruned. The cost of trimming and the loss in culls are much diminished and the shipping qualities of the grapes improved by proper pruning.

Finally, the useful length of life of the vineyard depends to a great extent on the pruning. Bad pruning not only results in large pruning wounds in vital parts but exposes the vine to serious mechanical injuries from the implements of cultivation. These wounds and injuries afford means of ingress to injurious parasites, borers of various kinds, and particularly to infection by black knot and wood-rot fungi. Irregularity of bearing, also, not only makes the vine more susceptible to attacks of this kind but occasional excessive crops may actually kill vines. Certain mistakes in pruning favor the growth of suckers, which appropriate the sap and cause drying up and final death of the crown and trunk.

HABIT AND CHARACTERISTICS OF THE VINE

Vitis vinifera.—With a few unimportant exceptions, all the vines grown for their fruit in California are varieties of *Vitis vinifera*, a plant originating apparently in the region south of the Caucasus but now growing wild throughout Western Asia and the Mediterranean countries and cultivated wherever the climate is suitable.

It is sometimes called the European vine because grown in Europe more largely than elsewhere, though many of our most valuable varieties originated in Asia and Northern Africa. The varieties are sometimes spoken of as Californian grapes because they are not grown east of the Rockies or to any great extent in North America outside of

California. They include all the varieties of vines grown in California except resistant stocks and a few *Labrusca* or eastern varieties, such as Concord and Pierce, which are grown to a limited extent. This difference of species between the varieties grown in the eastern states and in California accounts to some extent for the differences in methods of pruning, though the difference of climate is an equal if not more important factor.

Vitis vinifera and its varieties, like all true vines, are sarmentose plants, that is, they possess naturally long, slender, flexible trunks incapable of self-support, which attach themselves by means of tendrils to trees or other available support. If allowed to grow without restriction, they will grow to the top of high trees in a manner similar to the *Vitis Labrusca* of the eastern states or the *Vitis Californica* of the Pacific states. (See cover cut and Fig. 1.)

In vineyards, the natural habit of the vine is modified to a remarkable extent, principally by pruning. Most cultivated *vinifera* vines are given the form of a low self-supporting shrub with a short, rigid, vertical trunk. This complete change of natural form is accomplished without noticeable injury to the vigor or productive capacity of the plant. In some cases, however, it may be carried too far and certain varieties require to be allowed to develop in a somewhat more natural direction.

Structure of a Cultivated Vine.—The cultivated vine has a permanent framework, consisting of root, trunk, and arms, producing an annual growth of shoots, leaves, and fruit above ground, and of root-lets below.

The root and its branches extend in all directions through the soil wherever they find favorable conditions. Their extent is limited only by the competition of other roots or by mechanical obstructions. Their functions are to collect water and nutrient salts from the soil.

The trunk is usually vertical, but may be in part horizontal. It varies in length from one to two feet in low and from three to six feet in high vines. Its functions are the conduction and storage of food materials and the support of leaves and fruit.

The arms are the smaller divisions of the framework attached to the trunk. They vary in length from a few inches to a maximum of about eighteen inches. They may rise radially from the top of the trunk (*vase form*) or along its whole length (*vertical cordon*). They may be in one vertical plane at the top of the trunk (*fan-shape*) or along the whole length of the trunk (*horizontal cordon*). Their functions are the production of young wood and the proper distribution of leaves and fruit.

The young wood produced each year by the arms is utilized to form the spurs and canes which bear the leaves and fruit. Its total length



Fig. 1.—Trunks of *Vitis Californica*.

will vary in different cases from a few dozen feet to several hundred. In mature vines from 90 per cent to 98 per cent of all the growth is removed at each pruning.

In order to discuss pruning intelligently, it is necessary to agree on the definition of the technical terms used. The terms and definitions employed here are in nearly all cases those used by the majority of Californian grape growers. An attempt has been made to have them correspond as nearly as possible to the terms used in other countries and in the pruning of other plants. The main difficulty in this respect has been with the terms spur, sucker, water-sprout, and lateral. In these cases the usage of the majority of Californian grape growers has been followed.

TERMS REFERRING TO THE FORM AND STRUCTURE OF A CULTIVATED VINE

SUBTERRANEAN PARTS

Root Tips. The extreme ends of the rootlets.

Rootlets. The finest roots, the growth of one season. (*Fibrous roots.*)

Root Branches. All the divisions and subdivisions of the main roots older than one season.

Main Roots. The main root branches arising from the underground stem or tap root.

Tap Root. A single plunging main root or prolongation of the underground stem.

Root Crown. The base of the underground stem or region from which originate the main roots.

Underground Stem. The part of the trunk below ground from the bottom of which start the main roots or tap root.

AERIAL PARTS. (A) SKELETON OF FRAMEWORK AFTER PRUNING

Trunk or Stem. The unbranched body of the vine.

Head or Crown. The top of the trunk or region from which arise the arms or branches.

Branches. The main division (when long) of the trunk. Branches bear arms.

Arms. The main divisions (when short) of the trunk or branches. Arms bear spurs.

Spurs. Short pieces of the bases of canes, 1 to 4 nodes with their eyes.

Fruit Spurs. Spurs left for the production of fruit.

Wood Spurs. (a) *Renewal Spurs.* Spurs left to supply fruit spurs, or fruit canes for the following year, 1 to 2 eyes.

(b) *Replacing Spurs.* Spurs left to supply growth for the replacing of defective arms, 1 eye.

Fruit Canes. Canes left for fruit, 1½ to 6 feet long.

AERIAL PARTS. (B) ANNUAL GROWTH

1. *Before the formation of leaves*

Eyes. The compound buds on the canes.

Fruit Buds. Buds from which a shoot, bearing flowers, will be produced.

Wood Buds. Buds from which sterile shoots will be produced.

Base Bud. The lowest well formed eye at the base of a cane or spur.

Latent Buds. Buds which have remained dormant for one growing season or more.

Adventitious Buds. Buds arising from leafless parts of the wood.

Main Buds. The large central buds of the eyes.

Secondary Buds. The small lateral buds of the eyes.

2. *During the formation of leaves*

Shoots. The succulent growth arising from a bud.

Fruit Shoots. Shoots bearing flowers.

Sterile Shoots. Shoots not bearing flowers.

Water-sprouts. Shoots arising from dormant or adventitious buds.

Suckers. Shoots originating below the surface of the ground.

Laterals. Secondary shoots arising from buds in the axils of the leaves of the main shoots.

3. *After the fall of the leaves, before pruning*

Old Wood. Parts of the vine older than one year.

Canes. Young wood or growth of the current season, consisting of a series of *nodes*, each furnished with an *eye* and separated by the smooth portions called *internodes*.

Fruit Wood. Canes with fruit buds, usually growing out of two-year-old wood.

Sterile Wood. Canes without fruit buds. Those growing out of wood older than two years are usually unfruitful.

Roots.—The pruner has little to do with the roots except when planting or in cases where it is advisable to remove certain roots of young vines, either because they arise from the scion above the union or because they are too near the surface. Regular root pruning at intervals of several years is practiced in some regions, but there seems to be no sufficient reason for the practice in California. Some of the pruner's operations on the above-ground portions of the vine, however, may promote or restrict root growth.

Every year the vine makes a new growth of rootlets, and these rootlets are its sole means of obtaining water and soil nutrients. These it absorbs by means of the young cells and root hairs within an inch or two of the root tips. The rest of the root system serves to conduct the absorbed material to the aerial parts of the vine, to store reserve material for spring growth, and to hold the vine in place. The position, number, and vigor of the roots depend more on the nature of the soil and cultural operations than on anything the pruner can do.

The amount of root growth and that of top growth are mutually dependent. Conditions or methods which stimulate one stimulate the other and we can not curtail one without diminishing the other. The position of the root system is due partly to the nature of the variety or species of vine and partly to the conditions of penetrability, moisture, aeration, and food supply of the soil. The roots will go where the conditions are most favorable, and nothing we can do that does not change these conditions will affect the position of the roots except temporarily. The *rootlets* of a vine grown from a short cutting will finally occupy exactly the same position in the soil as those of a vine grown from a long cutting.

We can, to some extent, influence the position of the *main roots* by appropriate treatment of the vine when young. No main roots should arise nearer than four or five inches from the surface or they will be in danger of injury from the plow. The danger of shallow rooting is greatest in irrigated soils, and can be avoided by infrequent and deep irrigations, by avoiding a continually wet surface in the growing season during the first two years, and, when necessary, by removing the surface roots while they are small.

The best root system is that in which all the main roots arise from the root crown at the bottom of the underground stem. This does not prevent the utilization of soil at higher levels, for rootlets will grow into all regions of the soil where the conditions are favorable, whether below or above the main roots. No injury need be apprehended from the plowing up of small rootlets, as they will reform as fast as needed. The destruction of a main root, however, is harmful, as it not only destroys all the rootlets by means of which the root was feeding the vine but the large wound may allow decay organisms to attack the vine.

The supposed superiority of a tap root is a mere superstition, except in so far as it involves a perfect continuity of healthy tissue from trunk to root branches. Two, three, or more main roots from the root crown are equally effective, providing there are no unhealed wounds on the underground stem to be attacked by boring insects or decay fungi. (See Fig. 2.)

In wet soils there is usually a definite root crown at 6 to 8 inches below the surface. The planting of a long cutting will not alter this condition, as the roots simply start where the moisture, temperature,



Fig. 2.—Root crown of a four-year-old vine.

and aeration are most favorable, and all below this point dies. In drier soils a short cutting will make a similar root crown, but on a longer cutting the main roots may arise at various levels. There is no objection to the latter form of branching, providing some roots start at the bottom of the cutting and completely heal the surface. A root crown at the surface of the ground is very objectionable, as it is very

subject to injury from plow and hoe, and consequently subject to infection by black knot and wood rot fungi. It also makes clean cultivation and the perfect and economical removal of suckers difficult. A clean, smooth, healthy underground stem of at least six inches is very desirable.

The Trunk. The trunk is the body, we might almost say the life, of the vine. Its main functions are to support the bearing wood at the right height from the ground, to carry water and nutrient salts from the roots to the leaves and elaborated food from the leaves to the roots. On its continued healthy state depend the vigor, crop, and long life of the whole vine. It is a continuation of the underground stem and should be perfectly straight, smooth, and without wound, branch, or cane from the ground to the head. Its length or height depends on the variety, climate, and form of pruning, but should in all cases be sufficient to allow of close cultivation, easy hoeing, and proper suckering. This means a minimum of about ten inches. Except in certain forms of trellis and cordon pruning, it should never exceed thirty inches. A greater height is expensive to develop and sustain, and gives no corresponding advantage.

The trunk is formed during the first three years of the life of the vine. Defects acquired during this period can never be wholly remedied.

The *Head* of the vine is the top of the trunk or region from which the arms start. At first it is more or less indefinite, the spurs from which the arms finally develop being at heights varying six, eight, or more inches, but none nearer than six inches, from the surface of the ground. As the vine develops the arms are gradually brought to practically the same level by the removal of ill-placed arms before they become large, and a definite head is thus formed at the desired height.

Branches or long major divisions of the trunk are not used in any of the forms of pruning adopted in California. Their only use is for certain forms of high trellises or for covering an arbor. Where the trunk is simply elongated without branching or has only two horizontal branches at the same level, the form is called a *cordon*. In these forms there is no proper head or crown.

The *Arms* are the final divisions of the body of the vine and bear the spurs and fruit canes. They should be long enough to spread the crop so as to give all the bunches the necessary sun, space, and air to develop properly. They should not be long enough to interfere with cultivation nor to be in danger from the use of implements. The more vigorous the vine and the higher the trunk, the longer the arms should be. The correct length will vary from six to eighteen inches.

The arms constantly tend to become too long, and it requires skill, knowledge, and foresight on the part of the pruner to keep them within the required limits. Long arms tend to become weak and unfruitful and must periodically be replaced by new arms developed from as near the head of the vine as possible.



Fig. 3.—Carignane vine fifteen years old. Well formed trunk, head and arms; short spurs.

The *number* of the arms will depend on the style of pruning adopted and on the size of the vine. With very short pruning, the number on a mature vine will vary from three or four on a small growing variety in poor soil to ten or fifteen with very vigorous vines. With longer pruning, the number of arms is correspondingly decreased, and with long or cane pruning, two to four arms are all that should be given.

The *arrangement* of the arms depends principally on the planting plan and method of cultivation. When the vines are approximately equidistant in both directions and cross-cultivation is practiced, the arms should be arranged as symmetrically as possible in "vase-form."

When the vines are planted closer together in rows with wider "avenues" between them, especially when trellised, cross-cultivation is impossible. In these cases it is of great importance that the arms should be "fan-shaped," that is, arranged in a single plane. This makes it possible to plow and cultivate very close to the vine and even to cut out some of the ridge between the vines with horse hoes or cultivators. Care in shaping the young vines properly in this respect will obviate a great deal of expensive hand hoeing when the vines are large. The formation of the arms takes place principally during the third and fourth years, and mistakes made at this time can be remedied only imperfectly later and then at the cost of mutilating the vine. Trellised vineyards carelessly pruned in this respect often have a strip two feet wide along each row to be worked by hand. This strip can be reduced to six inches or less by carefully forming the vines when young.

At and near the ends of each arm are left pieces of young wood called *Spurs* or *Fruit Canes*, according to their length. The spurs vary in length according to their purpose. In ordinary short pruning most of the spurs are expected to produce fruit. Only fruit wood, that is, canes growing out of two-year-old wood, therefore, should as a rule be used for this purpose. The average length of a fruit spur is two nodes, which will give three eyes counting the *base bud* situated at the base of the cane or separated only by a very short node, which is not counted. Fruit spurs will vary in length, however, from one node to four, according, principally, to the vigor and size of the cane. The larger the cane the more eyes are left on the spur it furnishes.

A *Renewal Spur* is not left primarily for fruit. Its purpose is to furnish shoots from which the fruit spurs and fruit canes are formed the following year. In ordinary short pruning, the fruit spurs function at the same time as renewal spurs. In long pruning, one or two renewal spurs must be left below each fruit cane to supply fruit canes for the following year. Such spurs usually consist of two full internodes, but in some cases they may be reduced to a single node with two eyes, including the base bud. As renewal spurs are not intended for fruit, only a sufficient number should be left to insure enough properly placed canes for the next pruning. This number will be the same as the number of fruit canes with one, two, or three extra per vine to provide against the failure of some and, when necessary, for an increased number of fruit canes the following year. Sterile or fruit wood may be used for this purpose, as either will produce fruit wood for the following year.

The function of a *Replacing Spur* is to provide for the shortening or replacing of an over-elongated or otherwise defective arm. It con-

sists of only one internode and its eye, or even of simply the base bud, if this is well formed. As it is intended to replace an arm, it is chosen as near the base of this arm as is practicable without necessitating too large a wound when the arm is removed. Unless the arm is very defective, its removal is deferred until the year following that in which the replacing spur is left. In this way no crop is sacrificed. The first year the crop is borne as usual on spurs or canes at the end of the arm. The next year the replacing spur has produced fruit wood from which



Fig. 4.—Muscat vine, over fifteen years old. Trunk too short, arms too long, but head of good form.

can be formed a fruit spur which in turn develops into a new arm. A replacing spur consists always of sterile wood, as it is made from a cane growing out of old wood near the base of the arm. Replacing of arms should be done with sufficient frequency to avoid making the very large wounds that would be necessary if the arms were allowed to become very old and large. Spurs intended to produce new arms on developing young vines are left longer and usually consist of fruit wood, as they function as fruit spurs at the same time.

Some varieties of vines will not bear satisfactory crops on spurs, owing to the sterility of the buds near the base of the cane or to the small size of the bunches, which makes it difficult to obtain a sufficient

number from spurs to constitute a full crop. In such cases it is necessary to adopt some form of long pruning, with *fruit canes*. A fruit cane is a piece of the current year's *fruit wood* from one and one-half to six feet long. These canes should be taken, wherever possible, from canes growing out of two-year-old wood, in order to increase the probability of the buds being fruitful. Fruit buds may occur on water-sprouts more or less abundantly, according to the variety, age, and condition of the vine, but are nearly always much more abundant on "fruit wood." Canes less than two feet long are not advisable, as they are difficult to attach to the stake or trellis without breaking. No advantage, on the other hand, is obtained from fruit canes longer

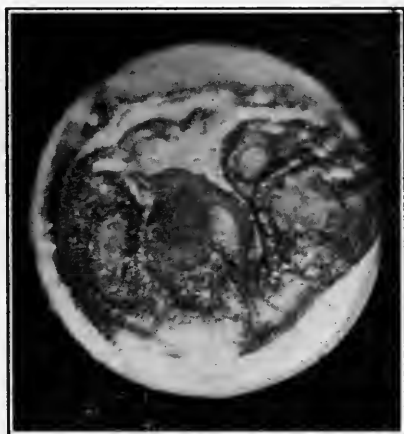


Fig. 5.—Cross-section through vine "eye" showing central main bud and two or three lateral secondary buds.

than six feet. Fruit canes six feet long will produce as many fruiting shoots as the vine can develop properly. Longer canes, indeed, usually fail to develop any more fruit, as a larger proportion of the buds fail to start, and even when more start the fruit is apt to be inferior in size and quality. Four six-foot fruit canes with five or six renewal spurs is about the maximum for the strongest vines with our methods of planting. More than this may sometimes increase the crop, but nearly always at the expense of quality and often with great danger of injuring the vine by over-bearing. This latter danger is particularly to be feared with vines grafted on resistant stock.

The buds on the canes are usually called *Eyes* by the pruner. This is a convenient term, as they are more than simple buds, and consist of a main central bud with one or two smaller secondary buds within the same bud scales. (See Fig. 5.)

The external appearance of all the eyes on a vine is similar. They differ, however, in the important respect that some are capable of producing a fruit-bearing shoot and others are not. The former are called *Fruit Buds*, the latter sterile or *Wood Buds*. If a thin section of a bud is examined under a low-power microscope, it is possible to determine its character. The embryo blossom bunches can be seen in the fruit buds. (See Figs. 5, 6.)

There is no external difference in appearance between fruitful and sterile buds, and the pruner has no means of determining with certainty whether an eye contains the possibility of fruiting or not. He can, however, tell what the relative probability of fruitfulness is with



Fig. 6.—Cross-section through fruit bud showing two embryonic blossom bunches.

different eyes, which, for this purpose, is all that is necessary. This he determines by the position of the eye relative to the cane and the vine. The greatest probability of fruitfulness occurs in the eyes of canes which have been produced by the spurs of the previous year. Or, as the pruner expresses it, the fruit buds are on the canes growing out of two-year-old wood. Canes produced by older wood, that is, which have grown from dormant or adventitious buds, are usually sterile.

The position of the eye on the cane is also of importance in judging its probability of fruitfulness. The base bud is usually sterile. The first and second eyes are usually fruitful with most vinifera varieties. With some varieties the probability of fruitfulness is not great until we reach the fourth or fifth eye. Beyond this point the eyes are usually fruitful until we reach a point where the cane is imperfectly

developed or badly matured. Sterility of the lower buds makes long pruning necessary.

A bud may be fruitful in varying degrees. A thoroughly fruitful bud of most vinifera varieties will produce, on the average, two bunches



Fig. 7.—Longitudinal section of a fruit bud showing an embryonic shoot with embryonic leaves and blossom bunch.

of grapes of full normal size. The number may be one, two, or three, according to variety. A less fruitful bud will produce fewer and smaller bunches. This reduction of fruitfulness may continue until

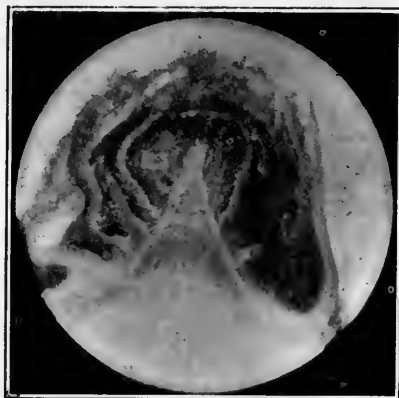


Fig. 8.—Longitudinal section of a sterile bud.

we find buds producing bunches which are little more than tendrils with a few grapes. Such buds are practically sterile, producing few blossoms or grapes. Their bunches are easily distinguished from the loose bunches due to the dropping of the blossoms without setting.

Wood Buds are those which contain no rudiments of blossoms and are therefore incapable of yielding fruit. They are distinguished by their position, which can be inferred from what has been said regarding the position of fruit buds. They occur principally on water-sprouts, and include usually also base, dormant, and adventitious buds.

Some of the buds left on a vine do not develop the first year, or produce only a few small leaves. Such cases are particularly frequent in long pruning. These buds will often develop the second year, especially if shorter pruning is adopted. These buds are called *dormant* or *latent buds*, and are usually sterile.

With the warm weather of spring the bud commences to swell, then to elongate, and finally produces a growing *shoot*, which pushes through the bud scales. This shoot is produced by the main bud. If the vine is vigorous and the number of buds limited, one or both of the secondary buds may start and produce smaller shoots. An injury to the main bud results in the starting of the secondary buds. Cut worms or other gnawing insects often kill the main bud without injuring the others. The same effect may be produced by a moderate frost after the shoots have started. A heavy spring frost will sometimes kill all the buds in a started eye.

The main buds on fruit wood usually produce *fruit-bearing shoots*. The rudimentary blossom bunches can be seen after the shoot has grown a few inches. There are usually two, or more rarely one or three. They may occur at the second and third, the third and fourth, or the fourth and fifth nodes. (See Fig. 9.) Shoots from the secondary buds may also produce fruit, but the bunches are smaller and less numerous.

A shoot coming from a dormant or adventitious bud on the old wood is called a *water-sprout*, and is usually sterile. A *sucker* is a shoot coming from below the ground. On vines which are properly handled the suckers are removed carefully and completely every year, so that few are produced, and as these must come from adventitious buds they are sterile. If the removal of suckers is neglected or imperfect, a shoot below ground may arise from the base of a sucker of the previous year, in which case it may be fruitful.

As a shoot grows it produces one leaf at each node on alternate sides. Opposite the second, third, fourth, or fifth leaf is produced a blossom bunch on fruit shoots and a tendril on sterile shoots. The next one or two nodes may also produce bunches or tendrils. As the shoot elongates further it produces more tendrils, but not at all nodes in vinifera varieties. Every third node is usually without a tendril.

In the axil of the leaf, that is, in the angle between the leaf stalk and the shoot, occurs a bud. Beside this bud very often arises a side shoot called a *lateral*. These laterals may be short or may grow long and form large *lateral canes*. Any injury to the growing tip of the main shoot stimulates the production and growth of laterals. Laterals



Fig. 9.—Blossom-bearing shoot of Tokay vine.

of some varieties may produce fruit like main canes. This fruit is the so-called *second crop*, and is usually about two weeks later than the main crop. Rarely these laterals may produce secondary laterals in their turn, which in a few varieties may produce a *third crop*. (See Fig. 10.)

We have on a vine, therefore, *fruit wood* and *sterile wood*, but this distinction is not absolute. Some of the buds on the fruit wood may

be sterile, while some on the sterile wood may be fruitful. The probabilities of fruitfulness, however, are so much greater in one case than in the other that the pruner may safely proceed as though it were absolute. Moreover, with proper pruning little sterile wood is produced. The difference between the two kinds of wood varies greatly with different varieties. On a Muscat of Alexandria most of the buds,



Fig. 10.—Fruit-bearing cane of Black Morocco, showing (I) first crop, (II) second crop, and (III) third crop.

even on water-sprout canes, contain rudiments of blossoms. The fruitfulness of all kinds of wood, moreover, depends on weather, soil, and cultural conditions. In some cases the conditions are so favorable to fruitfulness that even the water-sprouts bear. Hot summers, certain mechanical injuries to the vine, and grafting on certain stocks have a tendency to increase the proportion of fruit buds on all kinds of canes. On the other hand, cool summers, excessive growth of vine due to overabundance of water, or nitrogen in the soil may cause buds in all positions to be mostly sterile.

THE PRINCIPLES OF PRUNING

Physiological Principles.—The correct pruning of the vine is based on certain facts regarding plant growth and nutrition which the pruner should understand. Some of these facts apply to all plants; others are peculiar to the vine.

1. The vine prepares its food by means of the green coloring matter (chlorophyll) of its leaves. All the sugar, starch, and other substances which make up the body of the vine, and those of its crop, are elaborated in the leaves by means of the chlorophyll under the influence of sunlight. Carbon dioxide from the air and water from the soil furnish the main bulk, while the mineral salts from the soil furnish a smaller but equally necessary part. A certain area of green leaf surface functioning for a certain time is necessary to produce sufficient nourishment for the vital needs of the vine and for the production of the crop. Those leaves most exposed to the direct rays of the sun are most active in absorbing and producing food. The youngest leaves take all their nourishment from the older parts of the plant; somewhat older leaves use up more nutrient material than they absorb from the air. A young shoot may thus be looked on as, in a sense, parasitic upon the rest of the vine. After a certain stage, the leaves produce more food material than they utilize, and the excess goes to support other parts. The true feeders of the vine and of its crop, therefore, are the *mature*, dark green leaves.

This principle shows that any method which forces an unnecessary growth of young shoots or removes mature leaves, while still active, limits the possibilities of production both of wood and of fruit.

2. Within certain limits the *tendency* to fruitfulness of a vine or a part of a vine is inversely proportionate to its vegetative vigor. Within these limits, methods which increase the vegetative vigor diminish bearing, and, *vice versa*, methods which diminish vigor increase bearing. Failure to reckon with this fact and to maintain a proper mean between the two extremes leads, on the one hand, to comparative sterility and, on the other, to over-bearing and premature exhaustion of the vine.

The correct treatment of a vine is that which invigorates it as much as is possible without diminishing the crop.

3. Other conditions being equal, an excess of foliage is accompanied by a small amount of fruit, an excess of fruit by diminished foliage. This and No. 4 are corollaries of Principle No. 2.

4. Bending, twisting, or otherwise injuring the tissues of the vines or of its parts tend to diminish its vegetative vigor and, therefore, unless excessive, to increase its fruitfulness.

5. The vine tends to force out terminal buds and to expend most of its energy on the shoots farthest from the trunk. To keep the vine within practical limits, this tendency must be controlled by the removal of terminal buds or by measures which check the flow of sap and force the growth of buds nearer the stock.

Certain defective styles of pruning fail to recognize this tendency, and are therefore impracticable and can not be continued indefinitely. One of the commonest of these is the tying of fruit canes vertically to a stake.

6. The nearer a shoot or cane approaches the vertical the more vigorous it will be.

This principle is made use of in the Guyot and similar systems of pruning. The shoots from renewal spurs are tied up vertically to a stake and are thus rendered vigorous. On the other hand, the fruit canes are tied horizontally to wires, thus moderating the vigor and increasing fruitfulness.

7. The size of vines or parts of vines is inversely as their number, if other conditons remain the same.

Thus the fewer vines to the acre the larger each will grow; the fewer shoots allowed to grow on a vine or the arm of a vine the larger each individual shoot. This principle extends to the fruit. If we want large bunches, we must limit their number; if we want large berries, there must not be too many on a bunch.

Winter Pruning.—The principal pruning of the vine is done while the plant is dormant, between the fall of the leaves at the beginning of winter and the starting of the buds at the beginning of spring. In large vineyards it may be necessary to spread the pruning over most of this period; in smaller vineyards it is usually possible to prune in the month which is judged most favorable.

Season.—In deciding on the best time for pruning we must consider the convenience of other cultural operations and the effect of the period on the health and bearing of the vine.

For convenience, the earlier the pruning is done the better. Pruning in November or December gives abundant time to gather and to remove the prunings, to apply fertilizers, to plow, irrigate, and sucker and to tie up the fruit canes before the starting of the buds.

The effects of the time of pruning on the vigor and fruitfulness of the vine bear a close relation to the location and amount of reserve food material in the various parts of the plant.

During the summer the leaves feed the canes, trunk, and roots. Just before the natural fall of the leaves the canes contain the maximum amount of food material, viz., starch, sugar, cellulose, and other

carbohydrates. For two or three weeks, immediately following the fall of the leaves, much of these substances passes rapidly downwards to accumulate as reserves in the roots. Later, these reserves ascend again slowly, to supply the above-ground portions of the vine which, though dormant, still require nutrition. In spring, during the period just before and just after the starting of the buds, this upward migration of reserves is more rapid and continues until the young leaves are sufficiently developed to supply the vine with its carbohydrate food.¹

If we prune a vine, therefore, immediately after the fall of the leaves, the cuttings contain the largest amount of reserves and are in the best condition for use in grafting or planting. Three or four weeks later, the roots contain the largest amount of reserves, and if pruning is done then, they will be in the best condition to promote a vigorous growth in the spring. When the buds start in the spring, the root has lost some of its reserves, which have been used up by the canes during the winter. Pruning at this time, therefore, results in a less vigorous growth of shoots, but also, usually, in a better "setting" of the crop.

The effects of the time of pruning on the vigor and crop of the vine have been investigated by Professor Ravaz² in a series of experiments extending over seven years, with results which have been in the main corroborated by tests at the University Farm.

Vines pruned immediately after the fall of the leaves were the earliest to start in the spring. Those pruned when the vines were most dormant (end of December and beginning of January) started, on the average, four days later. Those pruned at the time pruned vines commence to bleed (about February 20 in the south of France) started about six days later. Pruning when the terminal buds commenced to swell (March) retarded the lower buds eleven days, and where the terminal buds had grown two or three inches, twenty days.

The starting of the buds was late, therefore, in proportion to the lateness of the pruning. One exception, however, was noticed. Vines pruned soon after the vintage and while still covered with green leaves started, on the average, ten days later than those pruned after the fall of the leaves.

The retardation of the starting of the shoots in the spring may be a valuable means of escaping the injurious effects of spring frosts. In one of our tests, the crop on nine rows pruned March 13 was saved, while that of twelve rows pruned November 19 and December 21 was completely ruined by a frost on April 21. Late pruning also retards

¹ Vidal, J. L., "Les reserves de la vigne," *Revue de Viticulture*, I, 895 to 903.

² Ravaz, L., "Taille hative ou taille tardive," 1912.

the blossoming, though to a less degree than it does the starting. Pruning as late as March may retard the blossoming ten days. The time of ripening is also influenced slightly in the same direction. When spring frosts occur, this influence appears to be reversed. The vines pruned early may blossom and ripen their fruit later. This is because, the frost having destroyed the first shoots, the only flowers and fruit that appear are on buds which have started after the frost.

Vines pruned before the fall of the leaves are weakened. Otherwise the time of winter pruning has little direct effect on the vigor of the vines. Professor Ravaz notes somewhat greater vigor in vines pruned earliest in the dormant season. On these vines the crop was diminished by frost. The extra vigor was due, therefore, probably not to the time of pruning but to the lack of crop.

Late pruned vines gave on the average larger crops. Professor Ravaz accounts for this by their escape from frost. The later blossoming, which increases the probability of warm dry weather for pollination, may also be a factor. At the University Farm Muscat vines pruned in the middle of April produced 22.6 pounds per vine, while vines pruned in December produced only 10.1 pounds, with no injury from frost in either case.

Pruning may be done, therefore, in frostless locations and with varieties which set their fruit well at any time when the vines are without leaves. Where spring frosts are common, the pruning should be as near the time of the swelling of the buds as possible. The benefits of late pruning without its inconveniences may be obtained by the system of "double" or "clean" pruning practiced in some regions. This may be applied in various ways. The simplest is to shear off all the canes to a length of 15 to 18 inches at any convenient time during the winter. This permits plowing and other cultural operations, and the final pruning is done in April. A better method is to prune the vines as usual but to leave the spurs with four or five extra buds. These spurs are then shortened back to the proper length as late as practicable. In some cases the method practiced in the Medoc may be used. This consists in leaving a foot or fifteen inches of cane beyond the last bud needed and removing all the extra buds at the time of pruning. The starting of the base buds is retarded by a piece of cane above them whether this piece of cane has buds or not.

Early pruning (December) promotes the vigor of the vine and results in early starting of the buds. Late pruning (March, April) promotes fruiting, may slightly weaken the vines, and results in late starting of the buds. Weak vines, those which have borne too much or which have been injured by insects or diseases, are better pruned

early. Very vigorous vines, especially in frosty locations, should be pruned late.

Amount of Pruning.—An average vine before pruning may have twenty-five canes, with an average of fifteen buds on each, or three hundred and seventy-five buds in all. If the vine is not pruned, all these buds will not start or produce shoots. Probably not more than fifty or one hundred will do so. If we prune the canes back so that we leave only fifty or one hundred buds, the same number of shoots will be produced. The only effect will be that buds nearer the bases of the canes will start instead of buds near the ends. (See *Physiological Principle No. 5*, p. 26). The quality and quantity of the crop and the vigor of the vine and its shoots will be influenced little if at all.

If we prune the vine more severely and leave only half this number of buds, a smaller number of shoots will be produced. As this smaller number has the same store of reserve material in trunk and root to draw on and the same root system to supply water and soil nutrients, each shoot will grow larger and more vigorously. See *Principle No. 7*, p. 26.) This smaller number of large shoots will produce approximately as much foliage as the larger number of small shoots on the unpruned vine, and the vigor of the vine is therefore not perceptibly diminished.

There will also be a smaller number of bunches produced, but each of these will be larger and have larger berries, so that the total weight of the crop will be as large as on an unpruned vine. In fact, the weight of crop will probably be larger, as it is easier for the vine to supply the water and sugar which constitute the main bulk of large berries than the stems, seeds, and skins which form a larger part of small berries.

We can increase the severity of the pruning, that is, diminish the number of buds left, still further, without materially influencing either the vigor of the vine, the amount of foliage, or the weight of crop. Beyond a certain point, however, the crop is diminished. There are two reasons for this. One is that there is a certain maximum size for the bunches and berries of any particular vine. When we have reached this maximum, any further decrease of fruit bunches results in a diminished crop. The other is that the excessive vigor given to the shoots is unfavorable to fruiting (see *Physiological Principle No. 2*, p. 25), often causing "coulure" or dropping of the blossoms without "setting." The pruner should endeavor, therefore, to leave just enough fruit buds to furnish the number of bunches that the vine can bring to perfection.

Beyond this point the crop is diminished and the vigor of the vine correspondingly increased. This increase of vigor is not the direct effect of the pruning, but of the curtailment of the crop, which frees a larger part of the energies of the vine for the work of growth and the building up of tissues and reserves. It seems highly probable that the direct effect of the pruning is really weakening, and that, if the only object were growth and vigor, it could be accomplished better by removing the blossoms in the spring and doing no pruning in the winter. The weakening effect, however, of even the heaviest pruning is probably much less than with most woody plants because the vine produces shoots from dormant and adventitious buds with so much facility, and the amount of growth and foliage than can be developed by sterile shoots in a single year is so great.

Heavy winter pruning, therefore, invigorates the vine by diminishing the crop. Light winter pruning increases the crop. If this increase is represented by a larger number of bunches than the vine can properly nourish, the crop will be inferior in quality and the vine weakened by over-bearing. On a mature vine of normal vigor, the pruner should leave the same number of spurs and fruit buds as was left the year before. If the vine appears abnormally vigorous, more fruit buds should be left in order to utilize this vigor in the production of crop. On the other hand, if the vine appears weak, it should be pruned more severely than the previous year, that is, fewer fruit buds should be left, in order to strengthen the vine by diverting its activities from crop production to building up tissues and replenishing its store of reserve food materials. Any attempt to make a weak vine bear a large crop can result only in further weakening of the vine and in the production of inferior grapes. By pruning such a vine for a small crop the grapes obtained will be of good quality and the vine invigorated so that it can produce normal crops in subsequent years.

These arguments apply not only to individual vines but to individual arms or canes of a vine. The number of fruit canes, spurs, or buds should be in proportion to the strength of the arm. A fruit cane or fruit spur should be longer the more vigorous it is.

The vigor of a vine is determined not only by the growth it has made but by the amount of reserves contained in its canes and body. Its condition in this respect can be determined by an inspection of the canes. These should be firm and heavy. Soft, pithy canes indicate weakness, and should never be left for fruit canes. If all or most of the canes on a vine are of this character, the vine should be pruned very short; in extreme cases, sufficiently short to prevent any attempt to bear. On the other hand, long, firm canes should be made to produce fruit by being left longer whether as fruit spurs or fruit canes.

The iodine test is useful in determining the condition of canes or vines in respect to reserves. For this test a solution of iodine in 75 per cent alcohol is used, 100 parts of alcohol to one part of iodine, by weight. A clean, slanting cut is made through the cane and a few drops of the solution placed on the cut. In three to five minutes a well nourished cane, containing abundance of starch (reserves), turns black all over the cut. An imperfectly nourished cane will turn black only on the medullary rays, which will show like the spokes of a wheel. If only a few black specks are produced by the iodine, reserves are lacking. In the first case the canes are good for use as cuttings or grafts and indicate that the vine is capable of producing a good crop. The pruning should be correspondingly generous. In the last case the cuttings are useless and the vine should be pruned very short. A few tests of this kind in a vineyard will give a fair idea of the amount of reserves in the vines, and such a test is a valuable aid in determining the amount of pruning to give.

Young and Old Vines.—During the first part of the life of the vine the main, if not the only, object of the pruner is to develop a framework of proper form. The methods of doing this and the time required will depend on the form aimed at and on the more or less favorable conditions for rapid growth. The crop during this formative period should be a secondary object. In fact, nothing is lost if it is left out of consideration altogether, except in so far as it affects the attainment of the desired form. Vines which are pruned so as to reach most rapidly and perfectly a desirable shape will not only bear more when they reach adult size but will practically always bear more fruit during the formative period than if the fruit alone were in view.

In pruning an adult vine, two objects must be kept in view: first, the production of the crop of the current year, and second, the maintenance of the proper form of the vine. Each of these objects is perhaps of equal importance. On the attainment of the first depends the current crop, on that of the second all future crops.

Units of Pruning.—When a vine has reached the stage of full bearing, pruning consists in leaving certain parts of the new wood for fruiting, other parts for renewal or the production of wood for the next year, and finally other parts for the replacing or shortening of arms. All new wood not needed for these purposes and all arms to be replaced are removed.

Whatever the system of pruning adopted, in all our Californian systems each arm of each vine is treated by the same method, modified only by the vigor of the individual cane, arm, or vine. There are two general methods used, viz., *spur pruning* and *cane pruning*. The

treatment of a single arm by either of these methods may be called the "unit of pruning."

The unit of pruning in spur pruning is illustrated in Fig. 11, representing a long arm about seven years old. At the end of the arm is shown the two-eye spur (S_2) of the previous year bearing two canes (C and C_1). Near the base of the arm is shown a single water-sprout (WS) growing out of old wood. Such an arm would normally bear other canes, but as they would all be removed entirely at pruning they are omitted to simplify the figure.

In pruning such an arm, one of the canes growing out of the spur of the previous year (S_2) is cut back to form a new spur and the other removed entirely. In deciding on which cane to use for the new spur,

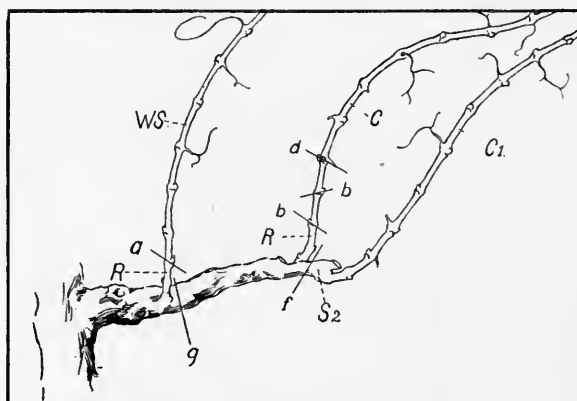


Fig. 11.—Unit of short pruning.

we must choose one that is suitable for fruiting, viz., well ripened, of moderate thickness, and with well formed buds. Of those which fulfill this condition, we must choose that which is in the best position to preserve the form of the vine. This, in most cases, will be the lowest (C in the figure), because it increases the length of the arm the least. If the lowest, however, is weak, broken, or otherwise unsuitable, we are obliged to take one higher up.

When a cane arising from the base bud of the spur of the previous year is chosen for the new spur, the length of the arm is lengthened imperceptibly. A spur from the first bud (C) will lengthen it usually little over an inch, one from the second bud (C) three or four inches. In any case, the arm finally becomes too long, like the one in the figure. It must then be shortened or replaced. This can be done by using a conveniently placed water-sprout for a replacing spur, as at R in the figure, and cutting back the arm in the place indicated by the line g .

This cutting back of an arm should be deferred until the following year, as the replacing spur will produce little or no fruit. In the meantime the fruit spur from cane *C* will bear a crop and the replacing spur *R* will produce fruit wood for the following year.

The cane chosen (*C*) is cut at *a*, *b*, or *d*, leaving a fruit spur of one, two, or three fruit buds and the cane, *C*₁, removed entirely by a cut at *f*. The more vigorous the variety and the particular cane the more buds should be left. The water-sprout is cut back at *a*, leaving a replacing spur of one eye. Of course, a replacing spur is left only in case the arm is too long and will require shortening the next year.

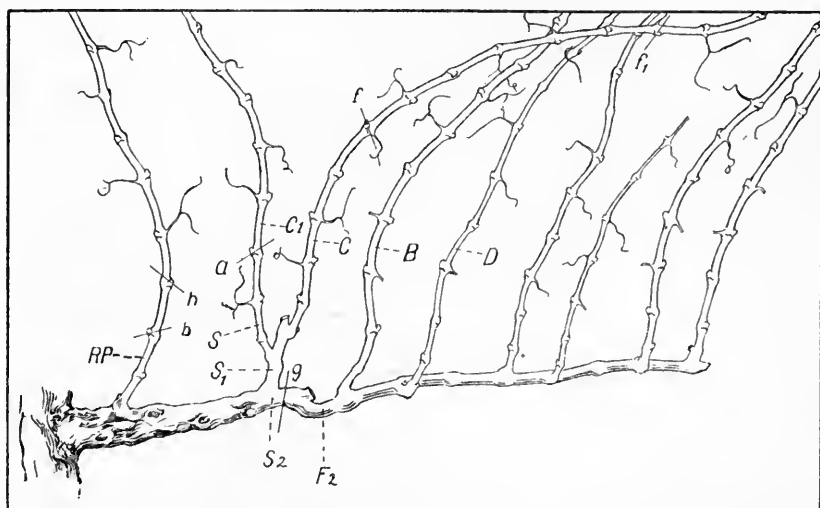


Fig. 12.—Unit of long pruning.

The unit in short pruning consists then of a single fruit spur of one, two, or three fruit buds.

The unit of pruning in long and half long systems is shown in Fig. 12, and consists of a fruit cane, *F*₂, with its renewal spur, *S*₁.

In the illustration, *S*₂ represents the renewal spur of two years previous. On it was left a fruit cane, *F*₂, which has produced the crop of the previous season, and a renewal spur, *S*₁, which has produced fruit wood for the present season.

In pruning, the fruit cane *F*₂ is removed entirely at *g*. The upper cane, *C*, of the renewal spur, *S*₁, is used for a new fruit cane and shortened to about *f* for half long and to about *f*₁ for long pruning. The lower cane, *C*₁, is cut back at *a* to form a renewal spur, *S*, which will produce the new wood for the next winter pruning.

This is the normal method of procedure, but various modifications are often necessary. If the cane, *C*, is unsuitable on account of lack of vigor, other canes such as *C*₁, or even *B*, *D*, near the base of the old fruit cane, may be used for a new fruit cane. The essential point is that the cane used for this purpose shall originate from *two-year-old* wood. In the same way any suitably placed cane may be used for a renewal spur. Water-sprouts from three-year, four-year, or older wood may also be used (*RP*). The essential point in this case is that the renewal spur shall be below the fruit cane, that is, nearer the trunk.

Replacing spurs for shortening the arms are occasionally needed, as in spur pruning, but usually the same spur can be used both for renewal and replacing. The water-sprout, *RP*, may be used for this purpose, cutting it at *h* or *b*, according to its vigor.

Summer or Herbaceous Pruning.—Summer pruning, of which there are many forms, consists in the removal of buds, shoots, or leaves while they are green or herbaceous, and is done therefore while the vine is growing or active.

The effects of summer pruning are in some respects very different from those of winter pruning and in some quite the opposite. If we remove a part of a cane in the winter, we do not weaken the vine at all; in fact, we may strengthen it indirectly by diminishing bearing. If we remove a growing cane in the summer, on the contrary, we weaken the vine because we remove leaves, which are its principal feeding organs and to which it owes its vigor. (See Principle No. 1, p. 25.)

This *weakening* effect is greatest in the middle of summer when the vine is most active and most in need of the food supplied by the leaves.

The removal of all the leaves by defoliating insects at this time may kill the vine. The danger is not so great early in the spring, when we can remove a certain number of small shoots without serious injury. In fact, vines struck by spring frosts are often more vigorous the following year, because the weakness due to removal of leaves is more than counterbalanced by the strengthening due to lack of crop. It is least harmful late in the autumn after the canes have matured and the leaves have begun to turn yellow.

The removal of growing shoots or parts of shoots also has an effect similar to that of winter pruning, viz., the concentration of the growth of the vine on the parts which remain. This *concentrating* effect and the weakening effect occur in inverse ratio and vary according to the time and method of operation. In early spring, at the starting of the shoots, the weakening effect is very slight and the concentrating effect

almost as marked as that of winter pruning. In early summer, with the vines in full growth, the weakening effect may be sufficient to completely neutralize the concentrating effect, i.e., the removal of some of the shoots may so weaken the vine that there will be no increase of growth in those which are left. Still later, the weakening effect may exceed the concentrating effect, i.e., the shoots which are left will make less growth than if none had been removed.

Uses of Summer Pruning.—Summer pruning has various uses, of which the principal are:

1. To direct the growth into useful parts of the vine: disbudding, thinning of shoots, and topping of young vines; suckering; water-sprouting.

2. To moderate the vigor of the vine and so increase its bearing: pinching, topping.

3. To increase the size of fruit (at expense of sweetness): topping.

4. To increase the shade on the fruit: topping or pinching to promote upright position of shoots and growth of laterals.

5. To decrease the shade on the fruit: defoliating.

Three other operations performed in the summer may be considered as forms of summer pruning, viz.:

6. Thinning of the fruit.

7. Ringing.

8. Removal of scion and surface roots.

Disbudding is practiced on young vines during the second and third years. It consists in removing the buds from the lower part of the stem of the vine in order to concentrate the growth in the shoots above and to avoid the production of canes low down where they would have to be cut off later. The buds are not removed until they have grown an inch or two. Many of them are dormant or adventitious and the attempt to remove them earlier would make it necessary to go over the vineyard too often. The sooner they are removed, however, the better, before they have used up much of the reserves of the vine and when the concentrating effect of their removal is at its maximum. On younger vines which have not yet formed a stem, it consists in removing all the buds but one in order to concentrate all the growth into a single shoot, from which the following year the stem will be formed.

Thinning of Shoots.—The purpose of this operation is the same as that of disbudding. It is done after the shoots have grown several inches or more. It is inferior to early disbudding, as it is more weakening to the vine and the concentrating effect is correspondingly less. It is simpler than disbudding, as it necessitates going over the vineyard only once. It is used principally during the second year for vines

which have been cut back to two buds at the end of the first season's growth.

Topping the Young Vines.—When by disbudding or thinning of shoots during the second year all the growth has been concentrated into a single shoot this shoot will grow with great vigor. When it has grown about twelve inches above the top of the stake, that is, above the height at which it is intended to develop the head, it should be topped. This topping has the effect of forcing the growth of laterals. These laterals may be used at the following winter pruning as fruit spurs and as the commencement of permanent arms. If this topping is not done, there may be very few buds on the cane when mature at the height at which it is desired to make a head. It will, therefore, be difficult to find buds in the proper place for the development of the arms and to produce the crop of grapes which the vine should yield the third year.

During the third summer the number of shoots will be small for the vigor of the young vine. They will grow rapidly and be very liable to be broken off by the wind while tender and succulent. If topped before they are long enough to afford sufficient leverage to the force of the wind, they will have time to lignify their tissues and become tough enough to withstand the pressure of the wind. Topping at this time helps to keep the shoots upright and makes it easier to give the arms the proper direction at the following winter pruning.

Suckering.—This is the removal of all shoots which originate at or below the surface of the ground. Neglect of suckering results in diminished vigor of the whole above-ground portion of the vine. The suckers bear little or no fruit, hence grow vigorously and appropriate the sap which should nourish the whole vine. Finally, the top may die, the whole growth go into the suckers, and all the benefits of a properly shaped vine will be lost. Such a vine can be renovated only by cutting off the old stump and building up a new vine from a vigorous sucker.

With grafted vines the consequences are even more serious. The suckers, coming from the stock, take the sap even more easily from the top, since the top is connected to the root by the grafting union, and the passage of water and food materials to the top is therefore impeded. A grafted vine which has been seriously weakened by the prolonged growth of suckers is useless and can not be renovated.

Suckering should be done with the greatest care and thoroughness during the first four or five years. This will save a great deal of expensive and troublesome work later. Very few suckers will be produced by vines which have been properly cared for in this respect

during the first three years, and such vines will usually cease to produce any after five or six years. Vines on which the suckering has been imperfectly done during the first three years, on the contrary, will always produce an abundant crop of underground shoots every year.

Suckering, like disbudding, should be done as early in the season as possible for the reasons already given. Another and even more important reason is that suckers which are removed late, and especially those which are allowed to grow the whole summer, promote the formation of dormant buds and of tissue which readily forms adventitious buds below ground.

It is necessary to sucker young vines two or three times during the spring. This is done every time the vines are visited for hoeing or tying up. When the suckers are soft and succulent they are easily pulled off without cutting. They must be removed completely from the base. When they get a little tough it is necessary to dig down to their point of origin for this purpose. It is worse than useless to remove a sucker partially. The part which remains forms an underground spur or arm which will be a source of perennial trouble.

Water-Sprouting.—This is the removal of sterile shoots. When it is done to prevent growth in places where growth is not wanted, or to concentrate growth in parts where it is wanted, it is advisable. The removal of all sterile shoots in all cases, on the theory that they are useless, however, is mistaken practice.

The growth of a large number of water-sprouts is usually a sign that the full vigor of the vine is not being used for the production of crop. The cure for this is longer, or a different style, of winter pruning. The production of sterile shoots on what ought to be fruit wood often indicates some cultural error, such as excess of water, nitrogen or humus, too late growth of the vine in autumn, or excessive vigor.

Water-sprouts may be removed with good results in certain cases. If the vines are weak, the growth may by this means be concentrated in the bearing shoots, which will thus be able to nourish their crop better. In this case the water-sprouts must be removed early, before they have grown more than a few inches. Otherwise the vine will be still further weakened and the trouble increased the following year. If the vines are excessively vigorous, diminishing the foliage by the late removal of water-sprouts may correct this defect. It is more reasonable, however, to utilize this vigor for crop production by a change in the winter pruning. Water-sprouts are sometimes troublesome by growing through the bunches, making it impossible to gather the crop without injury. This is particularly harmful with shipping grapes. Where much of this trouble exists it indicates that the vine

has an unsuitable shape. This can be modified in the winter pruning by spreading the vine sufficiently to allow all the bunches to hang free.

Sterile shoots are by no means completely useless. The foliage they produce nourishes the vine and makes it more capable of bearing fruit. They are needed for use as renewal and replacing spurs, for which purpose they are better than fruitful shoots, since they are more vigorous.

Pinching.—This consists of the removal of the growing tip of a shoot with thumb and finger. Its weakening effect is very slight, as no expanded leaves and a very small amount of material are sacrificed.

Its immediate effect is to arrest the elongation of the shoot. If this is done when the shoot is 15 to 18 inches long, the shoot has time to become sufficiently tough to resist the wind before it gets long enough to afford the wind much pressure surface. Shoots pinched as early as this usually produce a new growing tip from a lateral which later can not be distinguished from an original growing tip. Later pinching usually causes the growth of several strong laterals.

Pinching fruit shoots, just before blossoming, tends to make the fruit "set" better. It is, therefore, a remedy for "coulure." Pinching the first shoots on a fruit cane tends to promote the starting of other buds, and therefore the production of more bunches. By pinching we can accomplish most of the objects of topping with a minimum weakening effect on the vine. Fig. 9 shows a fruiting shoot at the proper stage for the first pinching.

Topping Bearing Vines.—This consists in removing one, two, or more feet of the end of a growing shoot, usually in June or July or later. In some regions topping is practiced regularly twice or even three times during the season. In general, it is used more in the cooler districts than in the hotter.

If practiced early, it has much the same effect as pinching. It tends to keep the canes upright and to cause the development of laterals. It involves the removal of leaves and is therefore weakening, which may be an advantage with extra vigorous vines. In very windy districts it is necessary to prevent the shoots from being broken off by the wind. The later the topping is done the more leaves are removed and the more weakening the practice is to the vine. Constant severe topping may have a serious effect on the vigor of even the strongest vines. Topping nearly always decreases the crop. Topping three times at Davis diminished the crop of Tokays by 32 per cent and of Carignanes by 42 per cent.

In general, moderate topping tends to increase the size of the grapes and to decrease their quality. For table grapes on vigorous vines it

is sometimes an advantage if not carried too far. At least three or four leaves should be left above the fruit when the topping is done early and seven or eight when the topping is done late. For wine or raisin grapes it is seldom advisable, as it decreases the sugar and flavor of the grapes. With long pruned vines, especially when trellised, it is often possible to obtain the benefits of the practice without its defects by topping only the shoots on the fruit canes and allowing the shoots on the replacing spurs to grow normally.

Both pinching and topping are used frequently with the object of protecting the fruit from sunburn, by increasing the shade for the grapes. For this purpose pinching is much superior to topping.

When a shoot is allowed to grow without interference it takes at first a more or less upright direction. As it increases in length its weight tends to bend it over to a more or less horizontal or downward direction. With some rapidly elongating varieties, the shoots bend over and take a reclining position, resting for a considerable portion of their length on the soil. With nearly all varieties they will finally bend outward and downward sufficiently to open up the center of the vine to the sun.

In many cases this opening up of the center is an advantage, promoting the coloring of the grapes and making easier the control of mildew. In some it encourages sunburn of the grapes. Sunburn, however, is not due alone to the direct rays of the sun, since some bunches completely exposed do not sunburn and others much shaded do. Sunburn occurs in vineyards where the shade temperature seldom goes above 100° F. and may not occur in others where it often rises to 110° F.

The commonest form of sunburn is due to an excess of evaporation over sap supply. If more water is lost through the skin of the grape than is supplied through the stem, it will dry up. An excess or a deficiency of water in the soil may curtail the sap supply and sunburn will result. Defective or diseased roots, wounds, or fungi in stems or arms may have the same effect. Increasing the shade, therefore, is merely a palliative, and any method which weakens the vine will increase the trouble.

If we pinch the growing shoots once or twice before they are three feet long, we increase the shade in two ways. First, they grow more upright as they are relieved from the weight of the growing top until they are sufficiently lignified to retain their upright position. Second, they produce laterals which increase the number of leaves near their bases and over the head of the vine. Topping, being done later, is less effective in these respects, and, moreover, as it involves the removal

of feeding leaves may weaken the vine so much as to increase the trouble.

Defoliating.—The development of the color of the grapes is influenced more by the light than by the heat of the sun. The coloring of Tokay grapes can sometimes be facilitated in the cooler districts by means which expose the bunches to more sunlight. One of these means is the removal of leaves. This, of course, will tend to weaken the vine. If the vines are excessively vigorous, this may not be a disadvantage. If only the leaves in the center of the vine, which have already commenced to turn yellow, are removed, the weakening effect may be very slight. Better insolation, however, can usually be obtained more profitably by changing the form of the vine or by thinning the bunches.

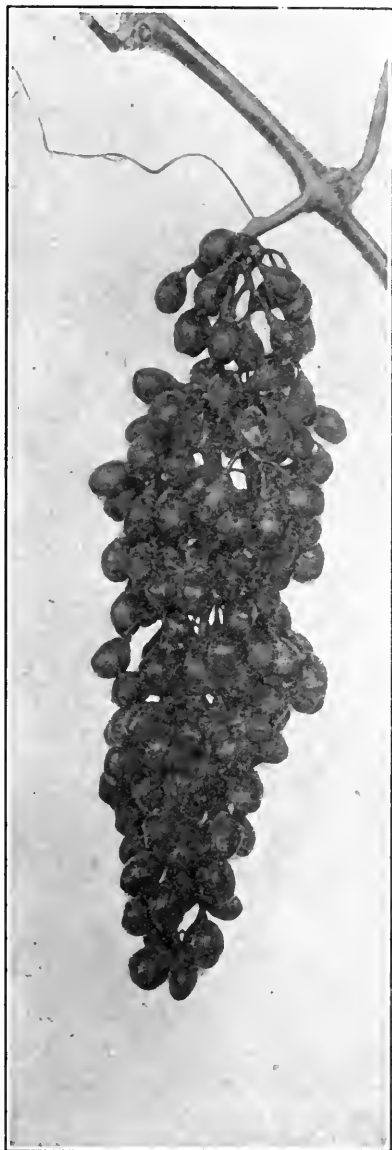
Removal of the interior leaves may be useful in some cases, with very late varieties, to protect them from molding after rains. It allows sun and air to reach the grapes freely and helps the moisture to evaporate quickly from their surfaces.

“Sheeping” the vineyard, or allowing sheep to eat the leaves immediately or soon after gathering the crop, is undoubtedly a bad practice. It removes the leaves before they have fulfilled their important duty of providing the reserve food to be stored up in cane, trunk, and roots for the growth of the following spring.

Thinning the Fruit.—Many otherwise suitable grapes do not ship well on account of the excessive compactness of the bunch. A compact bunch is difficult to pack without injury and can not be freed from imperfect berries without spoiling good berries.

This excessive compactness can be prevented by thinning before the berries are one-third grown. Thinning, moreover, increases the size of the berries, hastens ripening, promotes coloring, and lessens some forms of sunburn. The practice is regularly followed with success by many growers of Tokay, Black Morocco, Luglienga, and other grapes, whose bunches are usually too compact. While apparently costly, the expense is often more than counterbalanced by the saving in trimming of the ripe grapes. The increase of quality thus becomes a net gain.

The bunches are thinned at any time after the berries have set and before they have reached one-third their mature diameter. No bunches are removed, only a certain proportion of the berries of each bunch. The number of berries to be removed will depend upon how compact the unthinned bunches usually become. In general, it will vary from one-third to one-half of the total number. The thinning is effected by cutting out several of the side branchlets of the bunch. The branchlets should be removed principally from the part of the bunch which



A



B

Fig. 13.—Bunch of green grapes before (A) and after (B) thinning.

has most tendency to compactness, usually the upper part. The work can be done very rapidly, as no great care is necessary in preserving the shape of the bunch. However irregular or one-sided the bunch

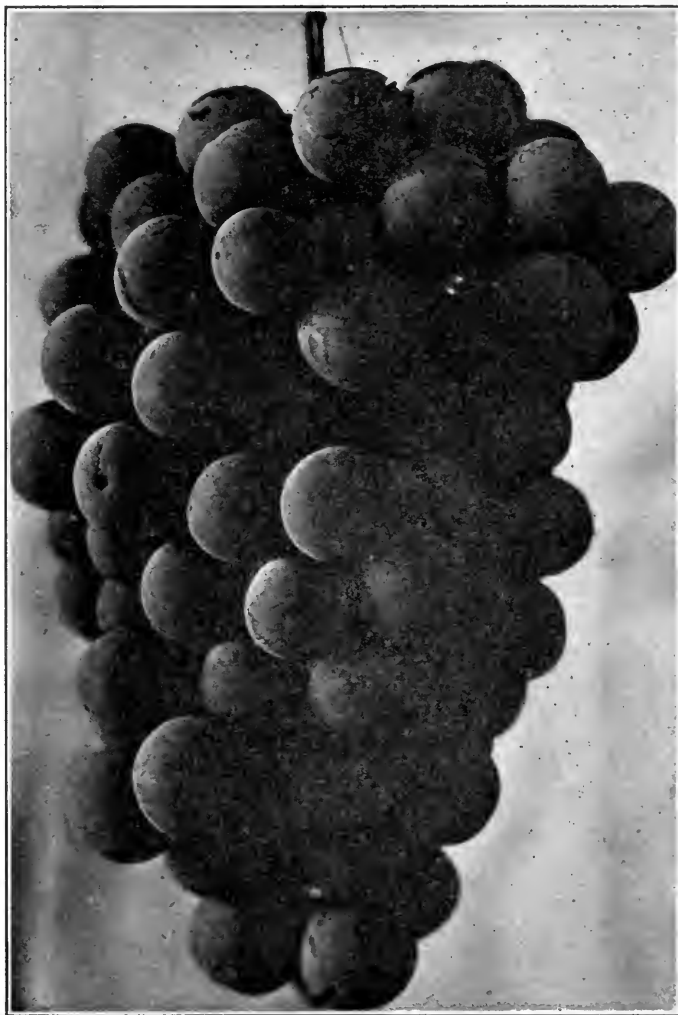


Fig. 14.—Black Morocco improved by thinning.

looks immediately after thinning, it will round out and become regular before ripening.

A long, narrow-bladed knife or a pair of grape-trimming scissors can be used conveniently for this work.

Ringling.—This operation, called also “cincturing” and “annular incision,” consists in the removal of a ring of bark from a growing shoot, a cane, an arm, or the trunk. It is performed by means of a special two-bladed knife (see Fig. 15) or other instrument, according to the size of the part of the vine to be treated. The ring is removed from a part of the vine below the fruit. This prevents the passage of food material to the lower parts of the vine and causes its accumulation in the parts above the incision.

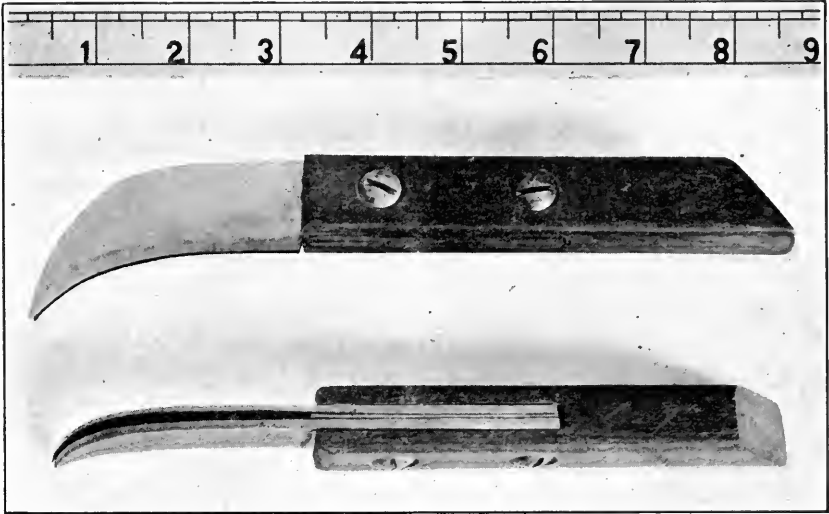


Fig. 15.—Cincturing knife.

The knife should not penetrate the wood and the ring of bark removed should be from one-third to one-fourth of an inch in width. If it is too narrow, the wound heals too quickly and the full effect of the operation is not obtained; if too wide, the part treated may die.

Ringling is used to (1) increase the size of the fruit and to hasten the ripening; (2) to prevent “early coulure,” the dropping of the blossoms without “setting”; (3) prevent “late coulure,” the dropping of the small, immature berries after setting.

For the first purpose the ringling is practiced on the cane just below the fruit or on the arm. It is done after the berries have set and reached about one-third full size. For the second purpose it is done a few days before the blossoms open, and for the third a few days after the berries have set.

All forms of ringling are more or less weakening to the vine, and it is seldom possible to treat the same vine in this way for several years

in succession without serious injury. An exception to this is the ringing of the Black Corinth in Greece and Australia, which has been practiced for years and has lately been tried with success in California. In this case the ringing is done to the main trunk at or near the surface of the ground and the wound is covered with soil immediately. This practice produces large and regular crops on a variety which usually bears hardly any crop without it.

Ringling the trunk in this way has proved much less dangerous than what at first sight would seem to be a milder operation, the ringling of single arms. The reason is, probably, that when the wound is protected by a covering of soil it heals perfectly, but when exposed as it is on an arm it fails to heal or heals only in part.

Removal of Surface Roots.—As has already been pointed out, the final position of the feeding roots depends on the soil conditions and can not be influenced by pruning. The position of the main roots can, however, be modified to some extent in certain cases.

Young vines in some soils tend to start roots at or very close to the surface of the ground. This is especially frequent where summer irrigation is practiced. If these roots are allowed to grow, they will form main roots and are liable to injury in cultivation. During the first and second year, therefore, it is advisable to cut off any roots which form within four or five inches of the surface. This can be done when the vines are hoed and suckered. When grafted vines are planted, the union is placed above the ground but is covered by "hilling" up the soil. This may cause roots to start from the scion. These roots must be carefully cut off before they become large or the vine will fail to nourish its resistant roots.

Restriction and Treatment of Wounds.—The possible length of life of a vine so far as we know is unlimited. The actual profitable life varies from a few years to fifty or more. Vines are sometimes killed by some disease or unfavorable conditons, such as severe frosts, prolonged drought, etc. Most vines fail and become unprofitable from the effects of an accumulation of small injuries. Among the chief of these are pruning wounds. Wounds are not only harmful in themselves by destroying wood, bark, and other conducting tissues, but they allow the entrance of boring insects and wood-destroying fungi whose effects are even more destructive.

All pruning wounds, therefore, should be made as small as possible, especially in the main body and other permanent parts of the vine. The necessity of making large wounds can be avoided to a great extent by using foresight.



Fig. 16.—Spore-bearing bodies of an “oyster-shell fungus” showing fungous decay of the trunk due to large pruning wounds.

Useless shoots and canes should be removed while they are small and young, and necessary renewals of arms or branches should be made before the part to be suppressed becomes too large. Where large wounds are unavoidable, they should be made as smooth as possible and protected by an antiseptic swabbing with 2 per cent copper sulfate solution and covered with a good white lead paint. The vine heals its wounds from the inside by the production of gummy matters or thyloses which fill up the cells and tissues and so prevent loss of sap. It



Fig. 17.—Proper position of pruning shears with relation to the vine when making a cut.

does not cover the wounds with healing tissue from the outside with the facility that many fruit trees possess. Wounds much over an inch in diameter seldom heal over completely.

By careful and skillful use of the pruning tools the harm of necessary wounds can be reduced to a minimum.

All cuts should be made clean and smooth. This requires that the shears should be of good quality and kept sharp. The cuts should be made in such a way that there is no splitting or cracking of the wood. This is accomplished by holding the shears in the proper way at the proper angle and by avoiding any undue bending of the portion of the vine to be removed. Canes for spurs should be cut at a slight angle, and not at a right angle to the grain. In cutting off a cane or spur

entirely the blade of the shear should be placed against the vine and should cut upwards as shown in Fig. 17. This will insure a clean, close cut without splitting. Any cut on the body of the vine should be made in such a way as to leave as small a wound as possible and at the same time to leave no projecting stub. Stubs of dead wood prevent healing over and interfere considerably with future pruning.

In spur pruning it is considered best to cut through the bud above the last one that it is desired to have grow as at *C* in Fig. 18. This leaves the woody diaphragm intact and protects the spur from injury. If the spur is cut at *C*₁, a long piece of internode is left exposing the pith. As this pith dries and shrinks it allows water to enter and forms an excellent place for molds to grow which may destroy the bud below. It requires some skill and practice to cut exactly in the right place; if by mistake the cut is made just below the diaphragm, the breeding place for molds has its maximum size. For this reason most pruners make the cut at *C*₂, about half an inch above the last bud. If the shears are sharp and the cut made at an angle of about 45 degrees behind the bud, no injury results.

In removing a piece of old wood at the base of a spur or fruit cane it is best to leave a little projecting stub. Too close cutting in this case is apt to injure the spur or cane. The projecting stub can be removed the following year, when the spur has grown larger, without danger of injury. (See Fig. 18.)

Supports.—With most systems of pruning, after the vine has reached a certain stage of development and its framework is complete, it will support itself after the manner of a small tree. Where the trunk is elongated, as in the Cordon systems, the trunk requires a permanent support.

Young vines in all systems require support for at least three or four years, and usually longer. A skillful pruner can build up a low vine without a support, but the results are imperfect at best and the method requires so much skill and care that there is no economic gain.

In long or cane pruning there must always be some support furnished for the fruit canes.

The supports needed then are of two kinds: (1) temporary supports to keep young vines in place until their trunks become large and strong enough to support themselves, and (2) permanent supports for long trunks or for the annual fruit canes.

Staking.—As temporary supports some form of stake is always used. Nearly all vine stakes in California are made of redwood, which is remarkably adapted to the purpose. It is light, easy to work, and very resistant to decay unless made from sap wood. Split stakes are

the best, as sawn stakes may be cut diagonally across the grain and many may break in driving.

Pine, spruce, poplar, willow, or any other wood may be used for temporary stakes if redwood is unavailable. Most of these woods will last two years, and can be made to last four or five if treated with

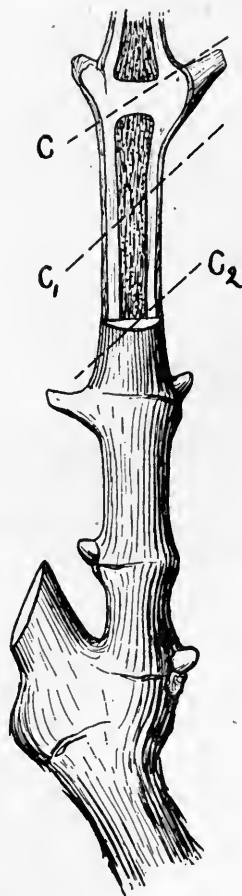


Fig. 18.—Methods of cutting the end of a spur.

copper sulfate. Saplings and small branches can sometimes be conveniently used. These should be peeled and pointed as soon as cut and then stood for twenty-four hours in a tub containing a few inches of a 5 per cent solution of copper sulfate (bluestone). At the end of this time the copper sulfate will have penetrated the whole stake and can usually be seen at the upper end. If the saplings are allowed to dry even for a few days, it will require a very much longer time to impregnate them with the antiseptic.

Other materials may sometimes be conveniently used for temporary stakes. The commonest of these is the Spanish reed or bamboo, *Arundo donax*, used in many places as a windbreak. These are somewhat slender for the purpose and require much readjusting, but will serve when better materials are not available.

The length of the stake depends principally on the height at which it is desired to head the vine and on the character of the soil. It should be of such length that, after being driven into the ground, sufficient will be below the surface to keep it firm and prevent its being loosened by the force of the wind acting on the vine tied to it, and sufficient will be above the surface to extend for two inches above the height at which



Fig. 19.—Pruning tools: one-hand shears; two-hand shears; curved saw.

it is intended to head the vines. Its thickness should be in proportion to its height.

When redwood is used a stake thirty inches long and one and one-fourth inches square will be sufficient in firm ground for small growing vines like the Zinfandel. This will allow fifteen inches to be driven into the ground and leave fifteen inches above, which is sufficient for vines to be headed at twelve inches. If the ground is loose or sandy, a slightly longer stake is advisable. For strong growing varieties such as Carignane or Tokay, especially when growing in rich soil, a stake two inches square and thirty-six to forty-eight inches long is necessary. This will permit the heading of the vine at eighteen to thirty inches.

When a stake is used as a permanent support for fruit canes it is usually made six feet long and two or two and one-quarter inches in diameter. A somewhat shorter stake, four to five feet, will suffice if the canes are bowed. A similar stake is needed for a vertical cordon.

Trellising.—A trellis consists of one, two, or rarely three wires stretched horizontally along the rows. The wires are held at the ends by heavy stakes or fence posts braced firmly. These wires are supported at intervals along the row by stakes of appropriate height. A tall stake at each vine is often used for this purpose, as it serves also for tying up the yearly replacing shoots. This stake, however, is expensive and troublesome in pruning, and is not indispensable. It is usually sufficient to place stakes at intervals of two or even three vines. Such stakes should be placed *between* the vines and need be long enough only to reach to the top wire. Some growers dispense with these intermediate stakes altogether. A temporary stake is used with each vine until it has developed a self-supporting trunk. The single wire used is then allowed to rest on the head of each vine. If the vines are even and well formed, this is a convenient arrangement, as it facilitates the tightening of loose wires and the repair of those which break.

The height of the first or only wire is usually about thirty inches, that of the second forty-five inches, and that of the third fifty-seven inches when three are used. In many cases one wire is sufficient to support the fruit canes. In windy locations the second wire is useful to support the growing shoots. With very vigorous vines the second wire may be used also for fruit canes. A third wire may be used in this case to support the fruit shoots, but is seldom or never really needed, and adds much to the cost of both installation and maintenance. The wire most used is No. 12 galvanized fencing wire. No. 10 or No. 11 is a little better, as No. 12 will frequently break. When more than one wire is used No. 11 for the bottom wire, which supports the weight of the fruit, and No. 13 for the others is satisfactory.

For the horizontal cordon system the same method of trellising is used.

For attaching the vines, canes, and shoots to stakes and trellises some form of rope or string is commonly used. The balls of twine used on self-binders are convenient and preferred by some. This twine, however, is not quite strong enough for the main body of the vine, especially in windy locations, unless doubled, though it is excellent for tying fruit canes to stake or trellis. A similar but heavier material called grape-twine is excellent. Old ropes, such as discarded ship cables, can sometimes be obtained cheaply, and, if cut into suitable lengths, the single strands are easily separated and form very good tying material.

It is false economy to use material for tying of insufficient strength or durability. It results in much troublesome extra work in retying or in defective vines.

In the hands of very careful workmen, nothing is better than wire for tying up young vines at the winter pruning. It holds the vine permanently and securely. Used carelessly, however, it may cut the bark, and unless discretion is used in the placing of the tie and care in its removal when necessary the vines may be girdled and killed. The wire from hay bales is suitable for this purpose, though it is unnecessarily heavy. No. 16 galvanized fencing wire is of about the right weight.

Other materials used are raffia for the fruit canes and osier willows for the body of the vine. Raffia is unreliable in strength and inferior for this purpose to binding twine. Nothing is better than osier willow to attach the trunk of a young vine to the stake, but it is rarely obtainable and requires some special skill to use.



Fig. 20.—Burning the brush in the vineyard after pruning.

Pruning Tools.—The best tool for pruning vines is a pair of shears of the Swiss form (see Fig. 19). If vines are properly pruned every year, it will seldom be necessary to make cuts too large for these shears, except when arms have to be replaced or last year's fruit canes removed. For this purpose a curved saw should be carried by the pruner. For vines which make a very heavy growth or which have been unskillfully pruned a pair of two-handed pruning shears similar to those used for tree pruning may be used. If these are of good form, kept sharp, and carefully used so as to avoid splitting the arms or cutting too deeply into the old wood, good work may be done with them.

Disposal of Prunings.—After the pruning is finished, the "brush" or cuttings must be removed. This is much facilitated if the pruners are careful in placing the wood they remove. The usual method is to place the wood from two adjoining rows in the space between them, either in a long line or in piles between four vines.

These rows or piles can then be carried by hand or with a hay fork and concentrated in large piles in the avenues or on the borders of the vineyard, where they are burned as soon as sufficiently dry. The heat from these fires is so great that it sometimes injures neighboring vines, especially if the burning is deferred until the starting of the buds. A better method is to use a brush burner. One form of brush burner is shown in Fig. 21. This consists of an iron truck with a perforated bottom. A fire is started in the truck, which is then drawn slowly



Fig. 21.—Vineyard brush burner.

down a free row by a quiet horse trained to the work. Two men collect the "brush" in the adjoining rows and throw it into the moving truck, where it burns without danger of injuring the vines, and at a lower temperature than in the large piles. The ashes are distributed equally over the vineyard. The method is difficult to adapt to trellised vineyards or to vines with fruit canes.

Gathering the brush with a hay rake is sometimes done, but is not satisfactory and is apt to injure the vines unless the rows are far apart. In some countries the vine prunings are used for fuel, for manure, and even for cattle feed, after cutting and crushing. The labor cost in California seems at present to prevent economical utilization in any of these ways.

Principle of Economy.—The skillful pruner directs as much as possible of the energy and growth of the plant into the permanent framework of the vine and into its fruit. The unskillful pruner allows the vine to grow canes, arms, or branches where they are not wanted and which must be cut off later. This is not only a complete loss to the vine thus deprived of all the removed material which ought to have gone into its permanent framework but the large wounds made are a source of weakness and shorten the life of the vine. The skillful pruner vitalizes the vigor of the vine by making it bear all the fruit it is capable of bringing to perfection. He properly distributes the fruit buds, leaving on each cane, arm, or vine just the number needed, without running the risk, on the one hand, of weakening the vine with an oversupply of poor fruit, or, on the other hand, of forcing it to excessive vigor and sterility.

To avoid waste in the development of a young vine, the pruner must have a clear idea of the form he wishes to give it. He must then, by appropriate and timely removal of buds and shoots, force the growth into those parts which are to form the permanent framework of his ideal vine. No cane, arm, or division should be allowed to grow more than one season which is not destined to be part of the final skeleton of the mature plant. In this way the vine will not only attain the desired form but will quickly reach bearing stature and be free from the large wounds, which are one of the main causes of premature aging. Part II of this bulletin will contain specific directions for applying these principles to the principal vines and regions of California.



VINE PRUNING IN CALIFORNIA

PART II

THE PRACTICE OF PRUNING

Pruning Systems.—The systems of pruning applied to the vine are innumerable. These systems differ in the form given to the body of the vine and in the management of the annual growth. Some of the differences depend on variations in the nature of the vines, on the cultural and growing conditions of the district, and on the objects of the grower. Others are unessential and merely a matter of taste. The best system is that which is most adapted to all the conditions of the particular vineyard. Any system which does not take into account the nature of the vine is defective.

Ideals of Pruning.—Before commencing work the pruner should form a mental picture of an ideal vine of the form desired. Vines are subject to so many accidents of weather, cultivation, and disease that even with the greatest care and skill it may be impossible to obtain a single ideal vine in the vineyard. The ideal vine, however, must exist in the pruner's mind, or all his vines will be unnecessarily defective. With this ideal constantly in mind, he is able to take such measures as will, as much as possible, direct the energies of the vine in the right direction and counteract all contrary influences, thus making each vine approach as nearly as possible the perfect model.

This mental ideal is particularly necessary in the treatment of young vines. Only when it is strongly impressed on the imagination is it possible to use such means and measures as will most rapidly and economically bring the vine to profitable maturity.

In the following account of the principal systems of pruning adapted to Californian conditions a description is first given of an ideal mature vine in full bearing. This is followed by a discussion of methods of handling a young vine to make it approach as nearly as possible this ideal, and finally by an account of the regular pruning necessary to make the vine produce maximum crops to a respectable old age.

Californian Systems.—The systems of pruning in use in California may be divided into two classes, according to the arrangement of the arms on the trunk of the vine. In the common systems there is a definite head to the trunk, from which all arms arise symmetrically at

nearly the same level. The vines of these systems may be called "headed vines." In the other systems the trunk is elongated four to eight feet and the arms are distributed regularly along the whole or the greater portion of its length. The vines of these systems, owing to the rope-like form of the trunks, are called "cordons."



Wild vine from Caucasia (*Vitis vinifera*).
The source of our cultivated grapes.

The headed vines are divided according to the length of the vertical trunk into high, 2-3 feet, medium, 1-1½ feet, and low, 0-6 inches. The cordons may be vertical or horizontal, according to the direction of the trunk, which is from four to eight feet long. The horizontal cordons may be single (*unilateral*) or composed of two branches extending in opposite directions (*bilateral*). Double and even multiple vertical cordons occur, but they have no advantages and are inadvisable.

The arrangement of the arms of a headed vine may be symmetrical in all directions at an angle of about 45 degrees. Such a vine is said to be "vase-formed," though the hollow center which this term implies is not essential. This is the form used in the great majority of our vineyards whether of wine, raisin, or shipping grapes. It is suitable for the "square" system of planting and cross-cultivation. Where vines are planted in the avenue system, particularly when trellised, and where cross-cultivation is impossible, the arms are given a "fan-shaped" arrangement in a vertical plane. This arrangement is essential for the economical working of trellised vines.

On the vertical or upright cordon the arms are arranged at as regular intervals as possible on all sides of the trunk from the top to within twelve or fifteen inches of the bottom. On the horizontal cordon the arms are arranged similarly, but as nearly as possible on the upper side only of the trunk.

Each of these systems may again be divided into two sub-systems, according to the management of the annual growth or canes. In one, spurs of one, two, or three eyes are left for fruit production. This system is called *short* or *spur* pruning. In the other, long canes are left for fruit production (*long* or *cane* pruning). In rare cases an intermediate form is adopted in which long spurs or short canes of five or six eyes are left. In cane pruning, each fruit cane is accompanied by one or two short renewal spurs. These must also accompany half-long pruning. Systems of pruning, where only long canes are left without renewal spurs, are not in use in California. In all systems replacing spurs are left wherever and whenever needed.

Other modifications are introduced by the manner of disposal of the fruit canes. These may be tied up vertically to a stake driven at the foot of each vine, or bowed in a circle and tied to this same stake, or they may be tied laterally to wires stretching along the rows in a horizontal, ascending, or descending direction.

The different systems differ therefore in: (1) the shape, length, and direction of the trunk; (2) the arrangement of the arms; (3) the use of fruit spurs or fruit canes with renewal spurs; (4) the disposal of the fruit canes.

The principal possibilities are shown in the following table:

A. HEAD PRUNING: VASE FORM

1. High trunk	$\left\{ \begin{array}{l} \text{with} \end{array} \right\}$	(a) Fruit spurs or
2. Medium trunk		(b) Half-long canes and renewal spurs or
3. Low trunk		(c) Fruit canes and renewal spurs; canes vertical or bowed.

B. HEAD PRUNING: FAN SHAPED; TRELLISED

1. High trunk: Fruit canes and renewal spurs; canes descending.
2. Medium trunk: Fruit canes and renewal spurs; canes horizontal or ascending.

C. CORDON PRUNING

1. Vertical: Spur; half-long; cane.
2. Horizontal-unilateral: Spur; half-long; cane.
3. Horizontal-bilateral: Spur; half-long; cane.

All possible combinations indicated by this table represent twenty-four variations. Some of these combinations, however, are not used and some are rare. The common ones are shown in Figs. 22, 23, 24, 25, and 26.

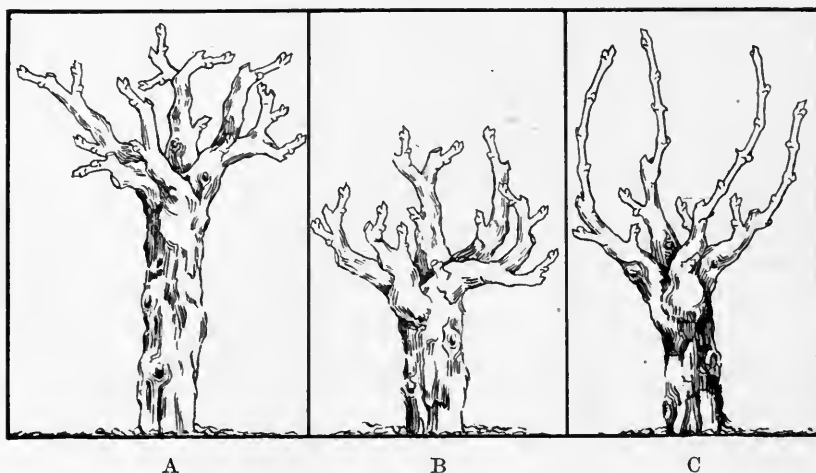


Fig. 22.—Forms of head pruning: A, spur pruning with high trunk; B, spur pruning with medium trunk; C, half-long with medium trunk.

Fig. 22 B represents a headed, vase-formed vine, with a medium trunk and short fruit spurs. This is the common system used in all parts of California, and is suited for all small growing vines which bear on the lower buds, for most wine grapes and for Muscats. The unit of pruning in this case is a fruit spur of 1, 2, or 3 internodes, according to the vigor of the variety and of the individual cane.

Fig. 22 A differs from 22 B only in the higher trunk and longer arms. It is commonly used for Tokay and other large growing varieties, especially when growing in rich soil and when planted far apart.

Fig. 22 C has the same form of body as A and B, except that the arms are somewhat less numerous. The unit of pruning is a short fruit cane of four to five internodes, accompanied by a renewal spur of one internode. It is suited for vigorous table grapes, which do not bear well on short spurs, being used especially for the Cornichon and Malaga in rich soil. This is a difficult system to keep in good shape owing to the tendency for all the vigor to go to the growth on the ends of the fruit canes. It is difficult to obtain vigorous canes on the renewal spurs. Occasional short pruning is usually necessary to keep the vines in proper shape.

Fig. 23 A is similar to 22 C in form, but the number of arms is still further reduced to 2, 3, or at most 4. The unit of pruning is a fruit cane of $2\frac{1}{2}$ to $3\frac{1}{2}$ feet with its renewal spur. Owing to the length of the fruit canes, they require support and are tied to a high stake.

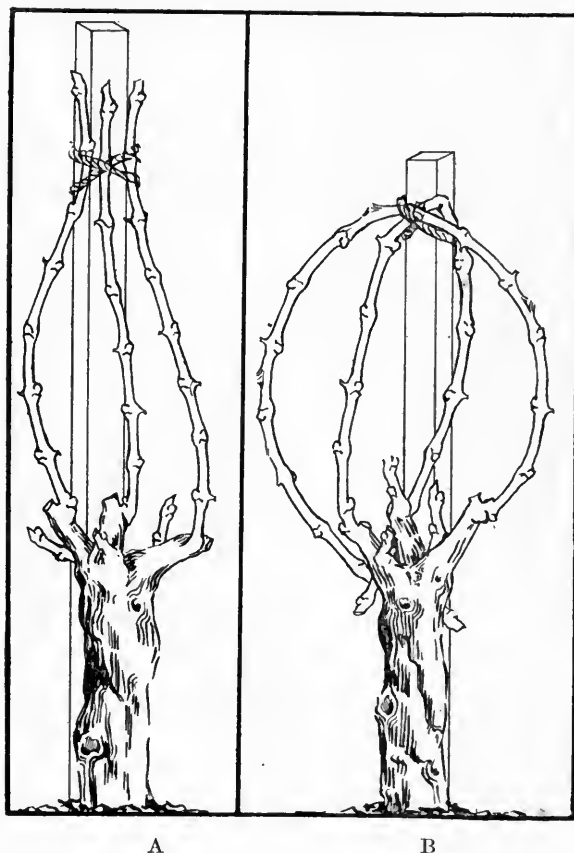


Fig. 23.—Forms of head pruning: A, vertical fruit canes and renewal spurs; B, bowed fruit canes and renewal spurs.

This method is used in a large number of vineyards with Sultanina, Sultana, and certain wine grapes, especially Semillon and Cabernet. It is not to be recommended, as it has several serious defects.

The difficulty of obtaining new wood from the renewal spurs is even greater than in the system shown in Fig. 22 C. The length and vertical position of the fruit canes cause the main growth and vigor of the vine to be expended on the highest shoots. (See *Physiological Principles* 5 and 6, p. 26, Pt. I) The renewal spurs are thus so shaded that, even though their buds start, the shoots make but a weak growth. The

result is that at the following pruning all the good new wood is at the top of the fruit canes of the previous year, where it cannot be utilized. The pruner then has to choose between reverting to spur pruning and getting no crop, or using the weak growth from the renewal spurs for fruit canes, in which case he may get blossoms but little or no fruit of any value.

Other defects of this method are that the fruiting shoots are excessively vigorous and therefore often tend to drop their blossoms without setting, and the fruit when produced is massed together so that it ripens unevenly and is difficult to gather. It also requires a tall and expensive stake.

Fig. 23 B represents an improvement on the last system. It differs only in the method of treating the fruit canes. These are bent over in the form of a circle and tied by their middle part to a stake which may be smaller and lower than that needed for the vertical canes.

This bowing of the canes has several useful effects. The change of direction moderates the tendency of the vigor of the vine to expend itself only on the terminal shoots. More shoots are therefore formed on the fruit canes and as their vigor is somewhat decreased they tend to be more fruitful. The slight mechanical injury caused by the bending operates in the same direction. (See *Physiological Principle* 4, p. 25, Pt. I.)

The excess of vigor being thus diverted from the fruit canes causes the renewal spurs to form vigorous shoots, which soon grow above the fruit shoots and obtain the light and air they need for their proper development. This method is used successfully for certain wine grapes such as Riesling, Cabernet, and Semillon. It is unsuited to large vigorous varieties or for vines on rich soil planted wide apart. In these cases two fruit canes are usually insufficient, and, if more are used, the grapes and leaves are so massed together that they are subject to mildew and do not ripen evenly. The bowing and tying of the canes requires considerable skill and care on the part of the workmen.

The body, arms, and annual pruning of the system shown in Fig. 24 are similar to those of Fig. 23, with the exception that the arms are given a fan-shaped arrangement in one plane. It differs in the disposal of the fruit canes, which are supported by a trellis stretching along the row from vine to vine.

This method is largely used for the Sultanina (Thompson's Seedless), and is the best system for vigorous vines which require long pruning, wherever it is possible to dispense with cross-cultivation. It is also suitable for any long-pruned varieties when growing in fertile soil.

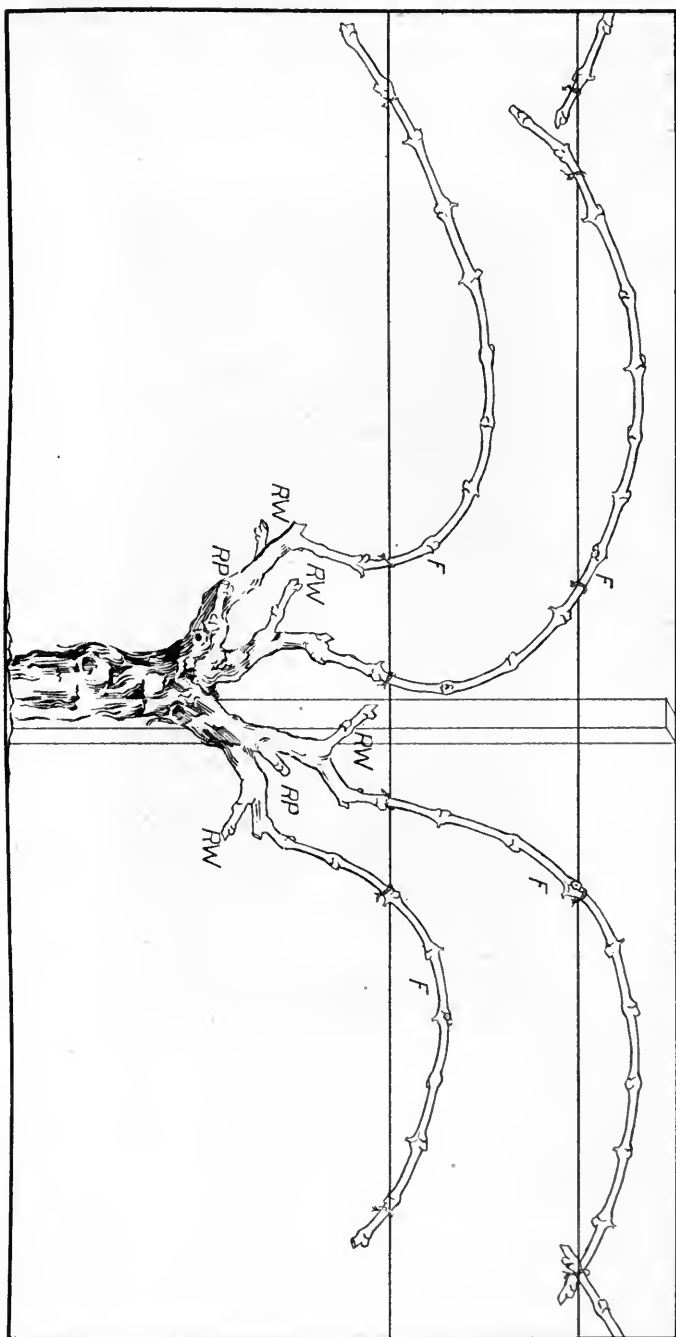


Fig. 24.—Head pruning: fan-shaped head; fruit canes tied to horizontal trellis.

Fig. 25 is a photograph of a four-year-old Emperor vine, illustrating the vertical cordon system. It consists of an upright trunk $4\frac{1}{2}$ feet high with short arms and fruit spurs scattered evenly and symmetrically from the top to within fifteen inches of the bottom. This system is used in many Emperor vineyards in the San Joaquin

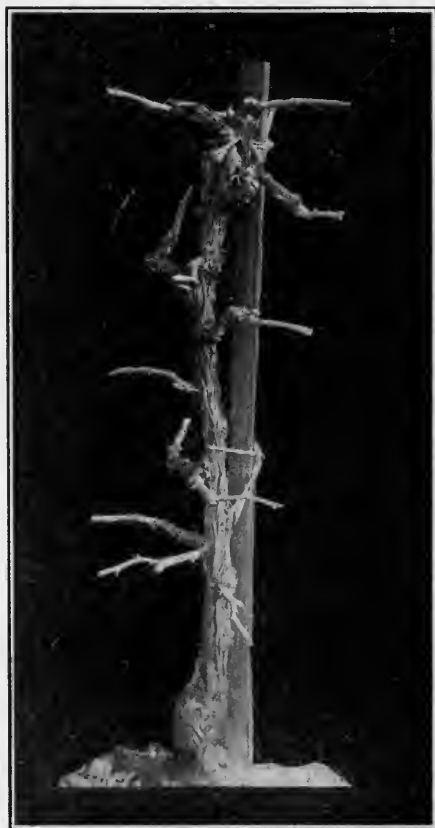


Fig. 25.—Single vertical cordon with fruit spurs.

Valley. Its advantages are that it allows the large development of the vine and the large number of spurs which the vigor of the Emperor demands without, on the one hand, crowding the fruit by the proximity of the spurs or, on the other, spreading the vine so much that cultivation is interfered with. It also permits cross-cultivation.

One of its defects is that the fruit is subjected to various degrees of temperature and shading in different parts of the vine and the ripening and coloring are often uneven. A more vital defect is that

it cannot be maintained permanently. The arms and spurs at the top of the trunk tend to absorb the energies of the vine and the lower arms and spurs become weaker each year until finally no growth at all is obtained below. After several years most of the vines therefore lose their character of cordons and become simply headed vines with abnormally long trunks. (See Figs. 64, 65.)

The cordon can be reestablished in this case by allowing a vigorous sucker to develop one year from which to form a new trunk the next. The following year the old trunk is removed entirely. An objection to this method is that it makes very large wounds in the most vital part of the vine—the base of the trunk.

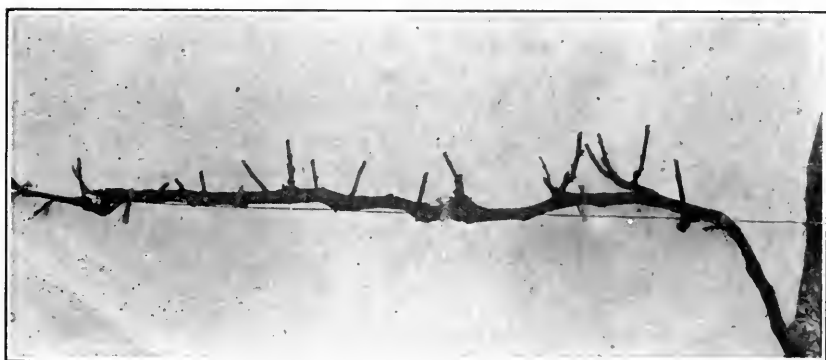


Fig. 26.—Unilateral horizontal cordon with fruit spurs.

Fig. 26 is a photograph of a four-year-old Colombar vine, illustrating the unilateral, horizontal cordon system. It consists of a trunk about seven feet long, supported horizontally by a wire two feet from the ground. Arms and spurs are arranged along the whole horizontal part of the trunk.

This system accomplishes the same purposes as the vertical cordon. It allows a large development of the vine and of numerous fruit spurs without crowding. It is superior to the vertical cordon in the distribution of the fruit, which is all exposed to approximately the same conditions owing to the uniform distance of the fruit spurs from the ground. All parts of the trunk producing an annual growth of wood and fruit are equally exposed to light and the tendency of the growth to occur principally at the part of the trunk farthest removed from the root is counteracted by the horizontal position. There is not the same difficulty therefore in maintaining this form of vine permanently that there is with the vertical cordon.

This system should not be used for small weak vines, whether the weakness is a characteristic of the variety or due to the nature of the soil. It is suited only to very vigorous varieties, such as Emperor, Almeria, and the Persian grapes, when these are growing far apart in rich, moist soil.

Periods of Development.—The first year in the life of the vine is devoted to developing a vigorous root system; the next two or three years to building up a shapely trunk and head, and a like period to forming the full complement of arms. At the end of from five to nine years the framework of the vine is complete and should undergo no particular change of shape except a gradual thickening of trunk and arms.

There are, therefore, several periods in the life of the vine, with varying objects, and the methods of pruning must vary accordingly. These periods do not correspond exactly to periods of time, so that it may be misleading to speak of pruning a two-year-old¹ or a three-year-old vine. One vine under certain conditions will reach the same stage of development in two years that another will reach only in three or four years under other conditions. The range of time of these periods is about as follows:

First period—Formation of a strong root system	1 to 2 years
Second period—Formation of stem or trunk	1 year
Third period—Formation of head	2 to 3 years
Fourth period—Complete development of the arms	2 to 3 years
Total time of formation of framework	6 to 9 years

Under exceptionally favorable conditions the first and second periods may be included in the first year and a completely formed vine may be obtained in five years.

Before Planting.—Cuttings, one-year-old rooted vines, or bench grafts are used for planting. In all cases they need some attention from the pruner. In Fig. 27 are shown the three forms of cuttings used in California. They differ only in length. The shortest eight to ten inches, are best suited for planting in the nursery; those of twelve to fourteen inches for planting in the field. The longest cuttings, sixteen to eighteen inches, are to be recommended only for the driest soils. In all cases they are cut at the bottom just below a bud. This facilitates the healing over of the base, as roots and healing tissue form most abundantly near a node. The top may be cut just

¹ *Age of Vines.*—There is a diversity of usage in denoting the age of a vine. In some localities a one-year-old vine means a vine that is in its first year; in others it means a vine that has completed its first year and is in its second. The former method is adopted here as the most convenient.

above a bud, so as to leave the protecting diaphragm or about one inch of internode, as in the figure.

Fig. 28 shows a bundle of good one-year-old rooted vines as they are usually prepared at the nursery. Before planting they must be pruned. The method of pruning depends on the size and shape of the vine and on the method of planting adopted.



Fig. 27.—Forms of cuttings.



Fig. 28.—One-year-old rooted vines.

Fig. 29 shows a good rooted vine of average size having a single cane at the top and several good roots at the bottom. The usual way to prune this is to shorten the cane to one or two buds and the roots to two or four inches, according to their size. Shortening the cane makes the vine less liable to dry out before rooting and forces the growth from the lower buds which produce more vigorous shoots. The roots are shortened so that there will be no danger of the ends being turned upwards when planted. If they are to be planted in a large hole, they may be left as long as five or six inches; if to be planted with a crowbar or dibble, they must be cut back to half an inch.

There is little if any advantage in leaving long pieces of roots. They are not feeding roots and are of no use to the vine until they

develop feeding rootlets. This they will do as well or better if shortened instead of being left full length. The main advantage of a rooted vine over a cutting is that it forms rootlets more easily and rapidly. There may be a slight advantage in leaving three or four inches of the sound well grown roots, as the reserve matters they contain probably promote a better growth of rootlets, but little or no difference has been noted between the growth of vines of which the roots have been short-



Fig. 29.—Rooted vine with single cane.



Fig. 30.—Rooted vine with two canes.

ened to one-half inch and those which have been left longer. Where the roots are left long, moreover, more care and time are needed in planting.

If the rooted vine has several canes, all but one should be removed entirely, and this one shortened to one or two eyes. The one left should be that which is strongest, has the best buds, and is the best placed. Fig. 30 shows the removal of a cane growing horizontally and two buds left on a vertical cane. Where a horizontal cane is left it should be cut back to the base bud. Otherwise the main growth may occur at a higher bud and the vine will have a crook which will result in a badly formed trunk.

If canes are growing from different joints, as in Fig. 31, it is usually best to leave the lowest cane if they are equally vigorous. This brings the buds from which growth will come nearer to the roots and leaves less of the original cutting, which are advantages. The upper joint between the canes is, moreover, often more or less decayed or imperfect.

Fig. 32 shows a vine pruned and ready for planting. Bench grafted vines are pruned in exactly the same way, but in this case it is necessary to take great care that all roots from near or above the union and all canes from near or below the union are removed.



Fig. 31.—Rooted vine with canes at two levels.



Fig. 32.—Rooted vine pruned ready for planting.

Fig. 33 shows a vine grown in the nursery from an unnecessarily long cutting. It was grown in warm, well drained soil, so that roots have formed at three levels from different nodes. Even in this soil, however, the conditions were not favorable for root growth at the bottom, so the last two nodes have formed no roots. If the cutting had been of five nodes instead of eight, it would have made a much better vine. The roots would have been less numerous but more vigorous. Such a vine can be pruned in one of three ways, according to the

character of the ground in which it is to be planted. In any case, the bottom two joints, without good roots, are cut off. If the soil where the vine is to be planted is deep and dry, the roots at the next three joints may be left and shortened to about one inch, as indicated in the figure. The roots are so numerous that none of them have grown large (see *Physiological Principles*, p. 25, Pt. I), and nothing would be gained by leaving them longer. For ordinary soils it would be better to remove the lower three joints and for wet soils the lower five.



Fig. 33.—Nursery vine with roots at different levels.

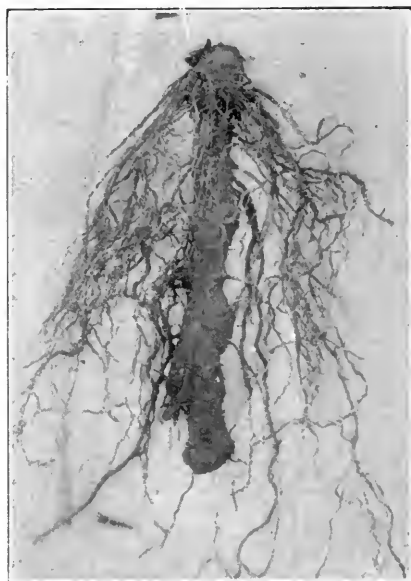


Fig. 34.—Result of planting too deep.

Fig. 34 shows the result of planting an unnecessarily long cutting or rooted vine. It represents the lower part of the underground portion of a vine two or three years old. The cutting or rooted vine was at least three joints too long, and the lowest part not only furnishes no roots of any value but is liable to decay, which may spread into the rest of the vine.

Fig. 35 shows the root growth during the first year in the field of a rooted vine of which the roots had been properly pruned and planted at the right depth.

Planting.—Cuttings made as directed are planted with the second bud at the level of the ground, leaving only one bud above. Rooted vines are planted with the two buds just above the surface. Bench

grafts are planted with the union just one inch above the surface. In the last case the soil must be hilled up so as to cover the union.

First Growing Season.—The treatment during the first spring and summer will depend on what growth the vines are expected to make and on whether the vines are staked the first year.

With cuttings and with both rooted vines and grafts where the growth will be moderate staking the first year is unnecessary, though it has some slight advantages. In these cases no pruning of any kind is necessary until the winter following the planting, except in the case

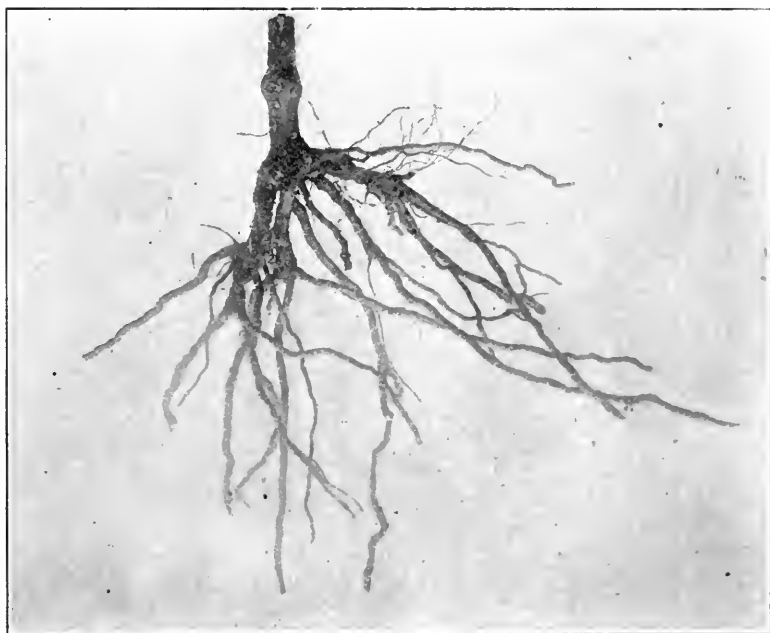


Fig. 35.—Roots of a young vine that had been properly pruned before planting.

of bench grafts. The pruning in the last case is confined to the removal of the suckers from the stock and roots from the seion. If the stocks have been well disbudded by the nurseryman, few suckers will develop. In moist soil the seion roots may develop vigorously, and must be removed before they grow too large or they may prevent the proper development of the resistant roots.

The removal of roots should usually be done some time in July. For this purpose the hill of soil is scraped away from the union and after the seion roots and suckers are removed it is replaced. In this second hilling up the union should be just barely covered so that the

soil around the union will be dry and unfavorable to a second growth of roots. Later in the season, about September, the soil should be removed entirely from around the union and any new roots that may have formed removed. The union is then left exposed to harden and mature, so that it will pass the winter without injury.



Fig. 36.—Growth of vine during the first summer.

Fig. 36 shows a grafted vine in July after the union has been uncovered for root cutting. It represents a good average vine at this period. Such a vine will usually support itself without a stake but if a stake is used it should be tied to it loosely. If the main shoot is kept upright, it will be easier to produce a well formed vine.

No disbudding, thinning of shoots, or topping need be done in this case. The object is to have as abundant a growth of foliage as possible

in order to stimulate a vigorous and abundant root development. (See Physiological Principle No. 1, p. 25, Pt. I.)

In some cases, where very good rooted vines of vigorous varieties are planted in rich soil abundantly supplied with water, it is desirable to disbud the vine early in order to throw all its energies into the single main cane. In such cases staking before or just after planting are necessary, and methods similar to those described for the second season are used.

First Winter Pruning.—At the end of the first growing season an average good vine will have produced from three to five canes, the longest of which will be from two to three feet long. (See Fig. 37 A.)

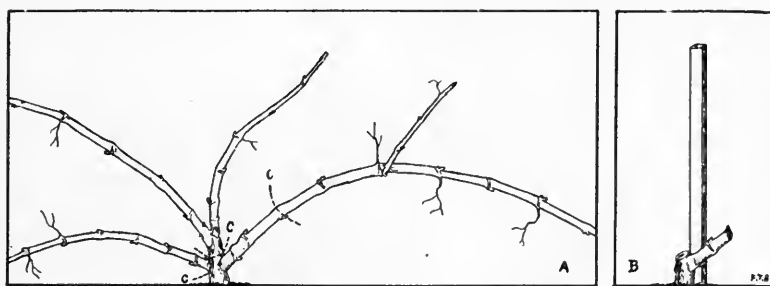


Fig. 37.—Vine at end of first growing season. First winter pruning; A, before pruning; c, c, places for making cuts; B, after pruning and staking.

Soon after the leaves have fallen in December or early in January, the vines should be pruned. The method is precisely similar to that used for rooted vines before planting except that the main roots are not touched. All the canes are removed entirely except one. This one should be well matured, at least at the base, and should have well formed eyes. It is shortened to two eyes. (See Fig. 37 B.) It is well also to cut off all shallow roots within three or four inches of the surface. This is necessary in the case of grafted vines if any have escaped the summer root cutting.

Some of the vines may have made an exceptionally large growth. Such vines may sometimes possess a cane large enough from which to start the trunk in the way described later for the second winter pruning.

Staking.—If the vines have not been staked before, the stakes should be driven soon after pruning and before the starting of the buds.

In order to preserve the alignment of the vineyard the stakes should be driven on the same side of every vine at a uniform distance. The

best distance is about two inches. If driven closer they may injure large roots, or even the main underground stem if the vines have not been carefully planted vertically or slanting toward the side on which the stake is to be placed.

The side on which the stake should be placed depends on the direction of the prevailing winds during the growing season. This side is the leeward. That is, the stake should be so placed that the wind will press the vine *toward* the stake instead of *away from* it. This will much facilitate the work of keeping the vine upright and attached to the stake. If the vine is on the other side the pressure of the wind will stretch the string tight and the swaying of the vine will gradually wear the string until it breaks, necessitating retying. By carefully observing this rule very few vines will require retying even if weak material like binding twine is used.

Second Summer Pruning.—Before the starting of the buds, in the spring following the planting, most of the vines appear about the same as when they were planted. (See Fig. 38.) There is, however, a very notable difference in that they have well developed root systems in the soil where they were formed. The result is that they make a much more prompt and early start and will produce a much larger growth than they did the first season. For this reason they require very careful attention from the pruner during the spring and summer of the second season. Vines neglected at this time, in this respect, may make as large a growth, but a large part of it will be wasted, the vines will be misformed, and it will require from one to two years longer to develop a suitable framework and to bring them into bearing, even though they are properly handled during subsequent years. The more vigorous the vines the more necessary it is to handle them properly during this period.

The main object during this second growing season is to develop a single, strong, vigorous and well ripened cane from which to form the permanent trunk of the vine.

This is done by concentrating all the energies of the vine into the growth of a single shoot. As soon as the buds start or when the most precocious has developed a shoot of a few inches in length, the vines should be disbudded (Fig. 38 A). This consists in rubbing off with the hand all buds and shoots except the largest and best placed. The lowest, upright shoot is usually the best. Leave only those which will make a straight vine. It is better to leave a less developed bud than a shoot which, when it grows, will make an awkward crook with the underground stem.

After this disbudding, the shoot left will grow rapidly, as it receives all the energies of the root system. When it has grown from ten to fifteen inches it should be tied to the stake (Fig. 38 B). Unless this is done it is liable to be broken off by a heavy wind, owing to its soft, succulent texture.

At the tying up of the reserved shoots all new shoots which have developed since the first disbudding should be removed. The shoots should be tied up loosely, as they are soft and easily injured, and they should be brought around carefully to the windward side of the stake.

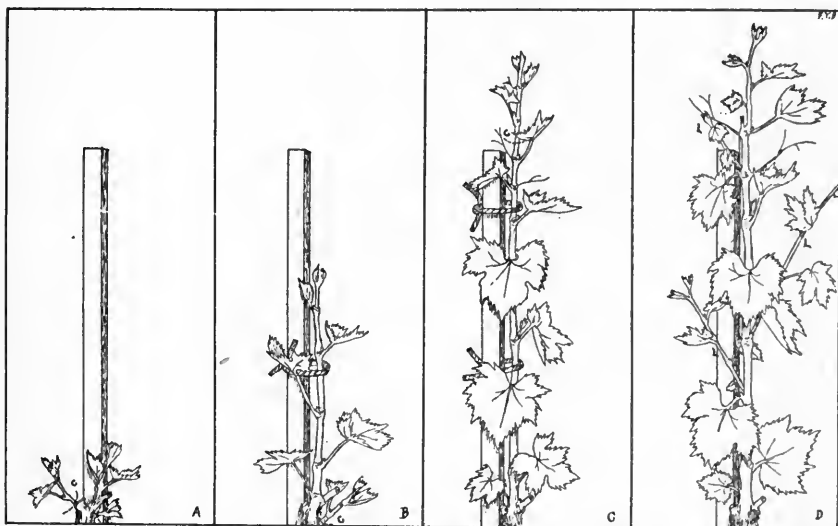


Fig. 38.—Growth and treatment of the vine during the second season. c, c, place where shoots are removed.

The shoots will require tying once more when they have grown another foot or eighteen inches. There will then be two ties, one at two or three inches from the top of the stake and the other at about the middle. If the vines have a tall stake and are to be headed very high, another tying higher up may be needed later (Fig. 38 C).

With vines making only a moderate growth, no other pruning will be needed until the winter. Exceptionally vigorous vines, however, may make a cane eight, ten or more feet long. Such a cane is heavy and is very likely to break the ropes by which it is attached to the stake. In this case it may break off at the bottom, or at least will form an awkward crook near the ground when it matures. In either case it is difficult to form a good trunk the following year. Even when the ties do not break, the cane will not be well suited for the commencement

of a trunk, as the joints will be so long that it will be impossible to leave enough well placed buds at the winter pruning.

Both these difficulties are avoided by timely topping. When such vigorously growing canes have grown twelve or eighteen inches above the top of the stake they are cut back about level with the stake (Fig. 38 D). This is most conveniently done with a long-bladed knife or piece of split bamboo. After topping, the cane ceases to grow in length and laterals start at most of the joints. It is less exposed to the action of the wind and the laterals supply the buds needed for forming the vine at the winter pruning.

The result of the second season's growth, then, has been to produce a single vigorous cane with or without laterals. This is the cane which is to develop into the final and permanent trunk of the vine. It must not only be large and vigorous but must be properly matured. If the vine is allowed to grow too late in the season, an early frost may destroy the unmaturing cane and much of the results of the year's growth will be wasted. Such a frost may indeed kill the entire vine. Grafted vines are particularly liable to injury from this cause, as, if they are killed down to the union, they are completely ruined. Ungrafted vines when killed to the ground may be renewed from a sucker the following year. This sucker, however, is likely to grow with such vigor that it is even more liable to injury from an autumn frost than the original shoot.

This late growth is much more likely to occur with young vines than with old. The old vines stop growing earlier because their energies are directed into the crop and as they produce a larger amount of foliage they draw more upon the moisture of the soil, which therefore dries out earlier.

Late growth of the young vines must be prevented and the wood matured before frost if possible. This is accomplished by means which promote the drying of the soil in autumn. Late irrigations should be avoided. Cultivation should usually stop by midsummer. In very moist, rich soils it is often an advantage to grow corn, sunflowers, or similar crops between the rows of vines to take off the surplus moisture. In some cases it is good practice to let the summer weeds grow for the same purpose.

Second Winter Pruning.—With vines which have been treated as described, and to which no accident has happened, the second winter pruning is very simple. It consists only in cutting back the single cane which has been allowed to grow to the height at which it is desired to head the vine.

Fig. 39 represents a vine which has been cut back to form a low medium head. It consists of a single cane which with the older wood at the base reaches nearly to the top of the stake, or fifteen inches. If properly treated this will develop into a vine with a trunk of about twelve inches, though this length can be modified slightly, as will be explained later.

This cane consists of about seven or eight joints or internodes, with an equal number of well formed eyes and an indefinite number of



Fig. 39.—Second winter pruning for head of medium height.

dormant buds, principally near the base of the cane or junction of the one and two-year-old wood. Only the buds on the upper half of this cane should be allowed to grow. These buds—about four—should give six to eight bunches of grapes and four, six, or eight shoots from which to form the spurs at the following winter pruning.

Fig. 40 represents a vine which has been cut back to form a high head. The cane is about twenty-four inches long and may be used to form a trunk eighteen inches high, though this height can be modified as in the last case. As with the shorter cane, only the buds on the upper half will be allowed to produce shoots. These—about six—should give ten to twelve bunches and the shoots necessary for the formation of spurs.

Fig. 41 represents a vigorous vine which had been topped during the summer, and consequently had formed well developed laterals. This vine has been cut back to the same length as that shown in Fig. 40. One bud has been left of each lateral giving thus three more buds to produce grapes and shoots.

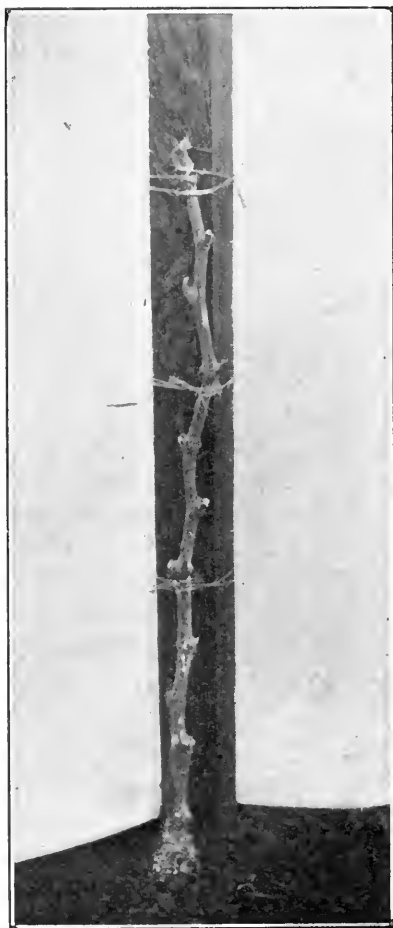


Fig. 40.—Second winter pruning
for high head.

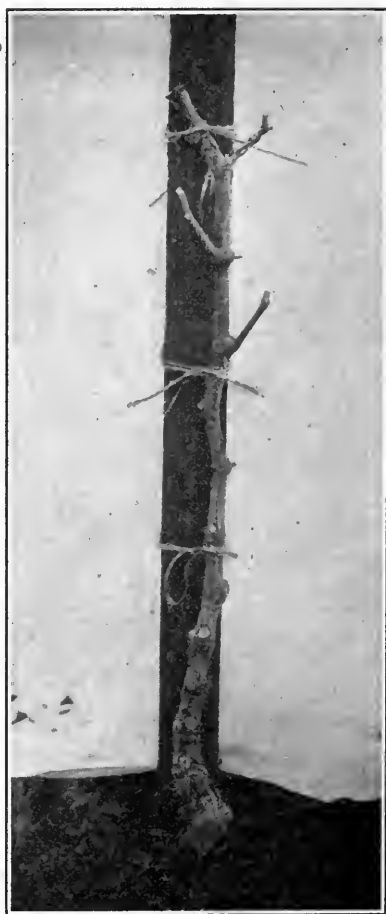


Fig. 41.—Second winter pruning
of very vigorous vine.

In all cases a full internode has been left above the top bud. This is done by cutting through the first bud above the highest which it is desired to have grow. This cut is made in such a way as to destroy the bud but to leave the diaphragm intact and part of the swelling of the node. This upper internode is left partly to protect the upper

bud, but principally to facilitate tying. By making a half hitch around this internode the vine is held very firmly. If the swelling at the node of the destroyed bud is not left, many vines will be pulled out of the hitch when they become heavy with leaves and supple with the flow of sap in the spring.

In tying the vines, no turns or hitches must be made around any part except this upper internode. A hitch below the top bud will result in a crook-necked vine as the top will bend over in the summer under the weight of the foliage. A hitch lower down is even more harmful, as it will girdle and strangle the vine.

A second tie about half way from the upper internode to the ground is always necessary to straighten the cane. Even if the cane is straight when pruned, a second tie is needed to keep it from curving under the pressure of leaves and wind in the spring. For high-headed vines three ties are usually necessary placed, as shown in Figs. 40 and 41.

For the top tie, wire is particularly suitable. It holds better than twine and does not wear. Even though it is not removed, it does no harm, as the part around which it is wound does not grow. The lower ties should be of softer material, as wire has a tendency to cut into the wood. They should be placed so that the cane is able to expand as it grows. With thin and especially with round stakes this means that the tie must be loose. With large, square stakes there is usually sufficient room for expansion, even when the twine is tied tight.

However careful the pruner, many of the vines cannot be pruned quite so simply as those described. These methods therefore must often be modified, keeping these vines in mind as ideals which the imperfect vines are made to approach as nearly as may be.

Some of the vines may not make a sufficient growth of cane to be tied up in the way indicated. Such vines should be pruned back again to two buds as at the previous winter pruning, and special care taken during the following summer to develop a good cane. Vines in which the development of the tying-up cane is thus delayed a year will usually make a very vigorous growth the following summer and must be topped. The result at the following winter pruning will be a vigorous cane with laterals, which should be pruned like the vine in Fig. 41. All vines which have not made a growth of well developed, mature cane of the length desired should be cut back to two buds. This length will usually be at least twice that of the desired height of trunk because the upper part of the cane is usually badly matured and with imperfect buds. It is bad practice to cut canes to intermediate lengths, as this results usually in crooked trunks and inevitably to variations in the height of the heads of different vines.

If the suckering, disbudding, and thinning of shoots have been neglected, there will be more than one cane on the vine. In this case all but the strongest and best placed must be removed and this treated like the single cane in Figs. 39 and 40. Unfortunately the strongest is



Fig. 42.—Third spring, ready for disbudding.



Fig. 43.—Third spring, cane too short.

often not the best placed. In fact, if tying up during the summer has been neglected it is often the worst placed. The more vigorous the vine the more likely is the position of the canes to be defective. This is especially true of grafts on old vines, which should be treated like exceptionally vigorous vines during the second growing season. In these cases of neglected vines the best canes are often lying flat on the

ground. It will require all the ingenuity and skill of the pruner to get them into a more or less erect position, and at the best they will result in crooked, misshapen vines.

By removing the soil from around the base of the vine the cane can often be raised more easily and the bend will then be at least partially in the underground stem, where it is less harmful. In the worst cases it may be impossible to raise a cane. It is then necessary to cut all the canes back to the old wood and to develop a new cane the next year.

Even if the main cane has been tied up, the removal of the other canes, if they are numerous and large, makes many serious wounds at the collar of the vine, which, in some cases, weaken the vine considerably.

Third Summer Pruning.—During the third season average vines, such as those represented in Figs. 39 and 40, will produce their first considerable crop and develop the canes from which will be formed the first arms.

Fig. 42 represents such a vine soon after the starting of the buds in spring. One vigorous shoot about three inches long has grown from the old wood and five fruit buds have started above on the cane. All the buds and shoots below the middle of the cane should be removed.

This will leave the four or five fruit buds and will give the vine the opportunity to produce eight or ten bunches of grapes. These buds will produce also at least four or five shoots. If the vine is very vigorous and the season favorable, they may produce eight, ten or more.

This figure will serve to illustrate how the height of the head can be modified later. When the five shoots grow the height of the head will be determined at the next winter pruning by which two of the corresponding canes are left as spurs. If the highest two canes are cut back to spurs and all others removed, the vine will be headed as high as possible, as these two spurs form the two first arms which determine the length of the trunk. If the lowest two canes are chosen and all of the vine above them removed, the trunk will be made as low as possible. Intermediate heights can be obtained by using some other two adjacent canes and removing the rest. It is often advisable to leave some extra spurs lower than it is desired to head the vine and to remove these lower spurs the following winter after they have borne a crop. For example, the three or four upper canes might be left, if the vine is vigorous enough, and the lowest one or two of these removed at the next pruning. This, however, is not often necessary with properly handled vines and is objectionable because it makes large wounds in the trunk.

Fig. 43 shows a vine of which the cane is too short. This was due to the accidental breaking off of the upper part of the cane. In this case it is best to remove all the buds and shoots but the uppermost two. Otherwise the vine may head out too low. Such a vine will usually make several shoots from each of the buds left, and while it will produce few grapes the current year, it will be in proper shape to produce a good crop the following year.

During this spring it will be necessary to sucker and remove low shoots at least once more. This can be done when the vines are hoed.



Fig. 44.—Vineyard during the third summer.

If the vines grow vigorously, the shoots should be pinched when they are eighteen to twenty-four inches long to protect them from the wind.

Fig. 44 shows a well grown vineyard towards the end of the third summer. The vines shown produced at the rate of five tons per acre, which may be considered about two-thirds of a full crop for full bearing vines of the variety, under the soil and climatic conditions of the vineyard. The crop of one of these vines left on the vine until after the fall of the leaves is shown in Fig. 45.

Third Winter Pruning.—At the end of the third season's growth the vine should have a straight, well developed trunk with a number of vigorous canes near the top from which to form the arms.

Fig. 46 represents a well grown vine at this period. No shoots have been allowed to grow on the lower part of the trunk and the five



Fig. 45.—Crop at end of third season.

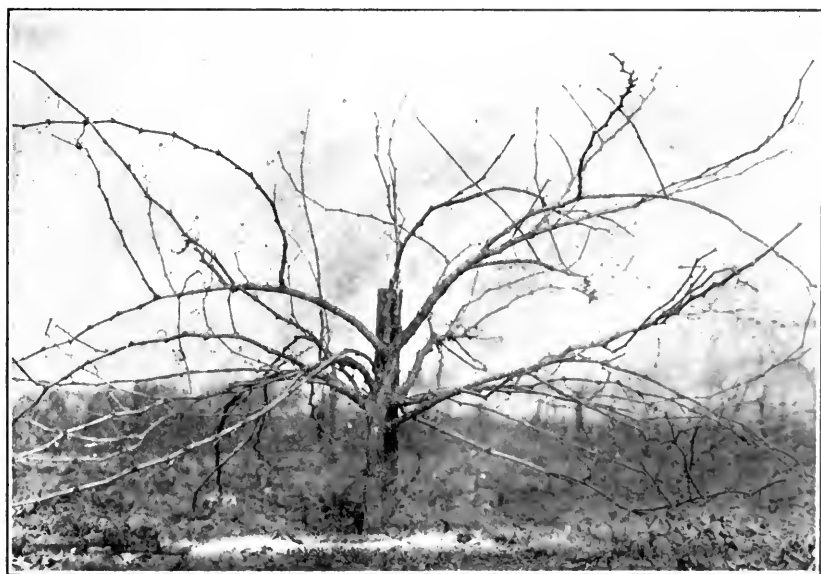


Fig. 46.—Three-year-old vine ready for pruning.

buds allowed to grow above have produced nine vigorous canes. The pruner should leave enough spurs to supply all the fruit buds that the vine can utilize. The number, size, and thickness of the canes show that the vine is very vigorous and can support a large crop. It will depend somewhat on the variety how many buds should be left. For a variety whose bunches average one pound, and which produces two bunches to the shoot, twelve fruit buds should give about twenty-four pounds or about seven tons per acre, if the vines are planted 12 by 6 feet, as these were. The number of spurs will depend on their



Fig. 47.—Vine of Fig. 46 after pruning for vase-formed head.

length. Six spurs of two buds each will give the required number, but as some of these canes are exceptionally vigorous they should be left a little longer, in which case a smaller number of spurs will suffice.

When the number and length of the spurs is decided on, the canes should be chosen which will leave these spurs in the most suitable position for forming arms. This position will depend on whether we want a vase-form or fan-shaped vine. In the first case, we choose those which will distribute the spurs most evenly and symmetrically on all sides, avoiding any which cross or point downwards.

In the second case, we choose only those canes which run in the direction of the trellis, avoiding canes which stick out between the rows. Downward pointing canes may be used in this case.

Fig. 47 shows the vine after pruning for a vase-formed head. The pruner has used two of the strongest canes to form two three-bud spurs and three of medium vigor to form three two-bud spurs. The head is of good shape, though some of the spurs are a little too low. One, two, or three of these may be removed at the following winter pruning and the permanent arms and head of the vine formed from canes



A



B

Fig. 48.—Three-year-old vines: A, pruned for a vase-formed, and B, for a fan-shaped head.

which develop on the two highest spurs. If the vine were too high, the head could be developed the next year from the three lowest spurs and the upper part removed.

Fig. 48 shows vines of the same age of practically perfect shape. Less spurs have been left because the vines were less vigorous. It is easier to properly shape vines which make only a moderate growth during the first three seasons. On the other hand, very vigorous vines

can finally be brought into practically perfect shape and the somewhat larger and more numerous wounds necessary are more easily healed by a vigorous vine.



Fig. 49.—Four-year-old vine pruned for vase-formed head.

Pruning After the Third Winter.—For the pruner who understands the pruning of young vines and has brought them to approximately the form represented in Figs. 47 and 48 the subsequent winter pruning is very simple. It involves, however, one new idea—the distinction between fruit and sterile wood.

Up to the third winter pruning this distinction is not necessary; first, because practically all the wood is fruit wood, and second, because the necessity of forming the vine controls the choice of wood. From this time on, however, this distinction must be carefully made. At each winter pruning a number of spurs of fruit wood must be left to produce the crop to be expected from the size and vigor of the vine. Besides these fruit spurs, it may be necessary to leave spurs of sterile



Fig. 50.—Four-year-old vine pruned for high vase-formed head.

wood to permit of increasing the number of fruit spurs the following year.

This will be made clear by comparing Figs. 48 A and 49. Fig. 48 A shows a vine at the third winter pruning with two fruit spurs of two buds each and one fruit spur of one bud, five fruit buds in all.

If these five fruit buds all produce vigorous shoots during the following summer, they will supply five canes of fruit wood which can be used to form five fruit spurs at the following winter pruning, which will be about the normal increase necessary. Some of these fruit buds, however, may produce weak shoots or shoots so badly placed that they

would spoil the shape of the head if used for spurs. Other shoots, however, will be produced from base, secondary, and adventitious buds which, while less fruitful, can be used to form spurs for the starting of new arms.



Fig. 51.—Seven-year-old Carignane vine with fully developed vase-formed head.

Fig. 49 shows a vine after the fourth winter pruning which had developed from a vine similar to that shown in Fig. 48 A. From the three fruit spurs left the previous year four canes have been chosen for the fruit spurs of this year. The old spur on the left has furnished two new spurs and the two old spurs at the right, each one new spur.

The pruner, judging that the vine is sufficiently vigorous to stand more wood, has formed two spurs from water sprouts which, though not likely to produce much fruit the first season, will supply fruit wood for the following year. The result is a very well shaped vine with six almost perfectly balanced spurs. These spurs will develop into permanent arms, some of them furnishing finally two or three.



Fig. 52.—Nine-year-old Carignane vine with well formed arms.

Fig. 50 shows a high-headed vine of the same age. It has five spurs, of which four are fruit spurs and one a spur of sterile wood left to shape the vine. The two more or less horizontal spurs on the right will bear fruit the following autumn and will be removed entirely at the following winter pruning, as they are badly placed. The arms of the vine will then be developed from the three upright spurs, which are excellently placed.

Each year thereafter the same process must be followed. First, enough fruit spurs, as well placed as possible, must be left to produce the crop. Second, on most vines, supplementary spurs of sterile wood must be left to supply more arms where they are needed, and finally, when the full complement of arms has developed, to supply new arms to replace those which have become too long or are otherwise defective.

Fig. 51 shows a fully formed Carignane vine with six well placed and well shaped arms. Such a vine will probably not need a larger number of arms, but care must be taken that none of those which it has become too long. This is the stage at which provision should be made for replacing arms when they threaten to become too long. The arm on the left will in two or three years extend too far from the head and will be in danger of being broken off. This year, therefore, a replacing spur should be left as near the head of the vine as possible. Such a spur can be formed from the upright water sprout which can be seen growing out of the three-year-old wood of the arm. One or two fruit spurs can be formed from the two fruit canes above this. After these fruit spurs have borne their crop the arm can be cut back to the replacing spur, which by that time will have furnished the necessary fruit wood. This cutting back to shorten or replace the arm may be done at the following or some subsequent winter pruning, according to the way in which the growth develops.

Sometimes it is difficult to find water sprouts in suitable positions for replacing spurs. This may be due to weakness of the vines, which are able only to develop shoots on the fruit spurs and have no surplus vigor to force out dormant buds on the older wood. This difficulty can be met by shorter pruning. If an arm is too long, and at the same time weak, it should be pruned to very short spurs. This will tend to force water sprouts to start from the older wood near the base of the arm.

The absence of water sprouts at the winter pruning may also be due to their having been removed during the summer. When water sprouts are removed the need of replacing wood should always be kept in mind and one vigorous, well placed water sprout left near the base of every long arm.

Fig. 52 shows an old Carignane vine in which this periodical shortening and replacing of the arms has been done systematically. The near side of the vine is nearly bare of arms. At the previous winter pruning a replacing spur was left right in the head of the vine on the near side. This produced a cane which is utilized this year as a fruit spur and which will develop into an arm. Another similar arm is being developed this year from a water sprout growing out of the old wood at the left.

Fig. 53 shows an old vineyard in which the vines have been kept in good form, though the heads are a little too low.

Fan-Shaped Vines.—With all headed vines the treatment up to the stage represented by Figs. 39, 40, and 41 is the same except for the variations in the height of the head. At the third winter pruning, however, the formation of the head commences, and the pruner determines whether it shall be *vase-formed* or *fan-shaped*. The production of a vase-formed head has already been described.

At the third winter pruning the vine should be pruned to two spurs, as shown in Fig. 48 B. More vigorous vines should *not* be given more spurs, as in Figs. 47 and 48 A, but the spurs should be made



Fig. 53.—Vineyard of fifteen-year-old Carignane vines with low medium trunks and vase-formed heads.

longer, with four, five, or even six eyes in some cases. This is in order to obtain some fruit, which might not be obtained from long pruning varieties by leaving many spurs. With extremely vigorous vines one fruit cane may be left at this pruning. The wires of the trellis should be put up this year, if this has not already been done.

Figs. 54 and 55 illustrate the second step in the production of a fan-shaped head. This form of head is used only for trellised vines and long-pruned varieties. The formation of the head and the management of the fruit canes are therefore conveniently discussed together.

By comparing the pruned vine, Fig. 55, with the unpruned, Fig. 54, the method of pruning will be made clear.³ The unpruned vine shows two arms, the spurs of the previous year, from one of which have grown three vigorous canes and from the other two somewhat less

³ By mistake the photograph from which Fig. 55 was made was reversed, so that the right side of Fig. 54 corresponds to the left side of Fig. 55.

vigorous. The pruned vine shows a complete unit, that is, a fruit cane with its accompanying renewal spur on the vigorous side and a spur for the production of fruit wood for the following year on the other side. If the vine had been more vigorous, two complete units would have been left and one or two extra spurs.

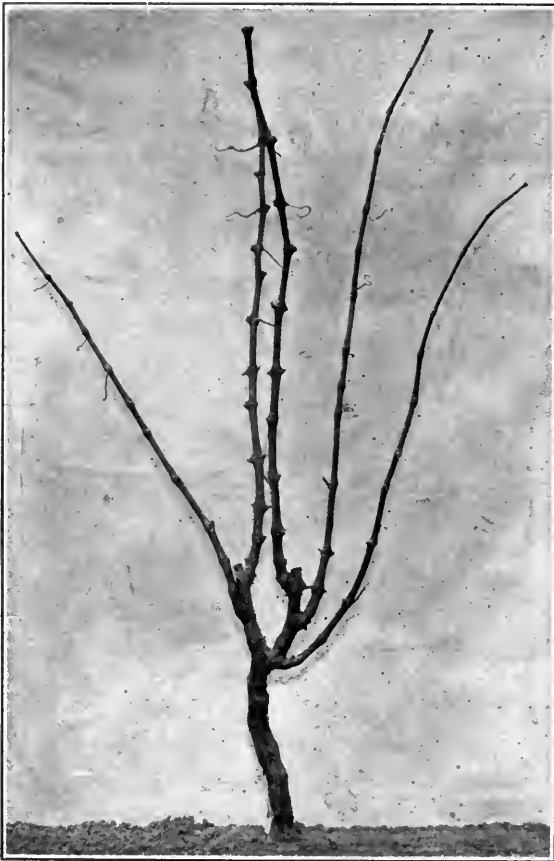


Fig. 54.—Before pruning.



Fig. 55.—After pruning.

As the form of the vine is determined by the renewal spurs, special attention should be paid to their position. In this case, the middle cane on one arm and the lower cane on the other have been used for renewal spurs. This brings them both to the same height above the ground and determines the place of the permanent arms. The next year each of these spurs will furnish a fruit cane and one or two renewal spurs. The arms will thus in two or three years be increased

to four, or, with very large vines, to six. These spurs should be chosen as nearly as possible in the plane of the trellis, that is, they should not project out sideways. Figs. 24 and 57 show vines of this kind of full size and in full bearing.

The fruit canes also should be as nearly as possible in the direction of the trellis, though this is not so important, as they can be bent over to the wire when tied up, and in any case they are removed the next year.

Fig. 56 shows a trellised vineyard of Sultanina. The vines are somewhat irregular and proper care has not been exercised in the choice of fruit canes and renewal spurs. Water sprouts have in some instances been used for fruit canes, and lack of care in the selection



Fig. 56.—Trellised vineyard of Sultanina. Pruning defective.

of renewal spurs is responsible for the awkward, ungainly arms. A vineyard such as the one shown will not only not bear so large a crop but will cost twice as much to prune as one in which the vines are kept in the proper shape.

Fig. 57 shows the crop on a trellised Sultanina pruned by the system under discussion. It shows the regular open distribution of the grapes, all at about the same distance from the ground. Such grapes develop and ripen equally and perfectly.

Double-Headed Vines.—Some growers attempt to arrange the arms of their vines in two stages, one above the other, forming double-headed or two-crowned vines. The method is applied to both vase-formed and trellised vines. It is open to the same criticisms as the vertical cordon, the chief of which is that it cannot be maintained permanently. The



Fig. 57.—Trellised Sultanina vine.

lower head or ring of arms finally becomes weak and fails to produce wood.

A double crown can be maintained in trellised vineyards, and has some advantages, the chief of which is that it makes it easier to keep the vine in the single plane and to prevent arms getting into the inter-rows. Fig. 58 illustrates a method of starting a double crown in a trellised vineyard. The vine represented is four or five years old. Finally it will have two full units on each side. The double trunk is

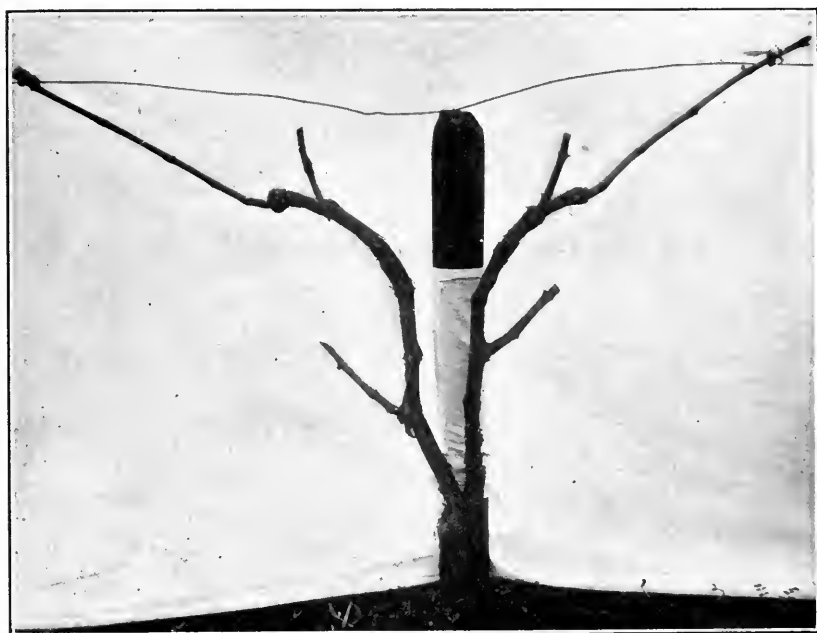


Fig. 58.—Trellised vine with double head.

not necessary, and is, in fact, a disadvantage, as one trunk has a tendency to grow at the expense of the other.

Vertical and Bowed Canes.—Figs. 59 and 23 A show long-pruned vines in which the fruit canes have been tied vertically to a tall stake. This is a method used commonly in many vineyards. The unit of pruning is the same as in the method just described, consisting of a fruit cane and a renewal spur. The framework of the vine consists of a trunk of medium height, with a vase-formed head consisting of three or four arms. The defects of this system have been pointed out on pages 59 and 60.

It is used with fair success with seedless Sultanas and with some wine grapes such as Colombar, Semillon, Cabernet, and Reisling, in

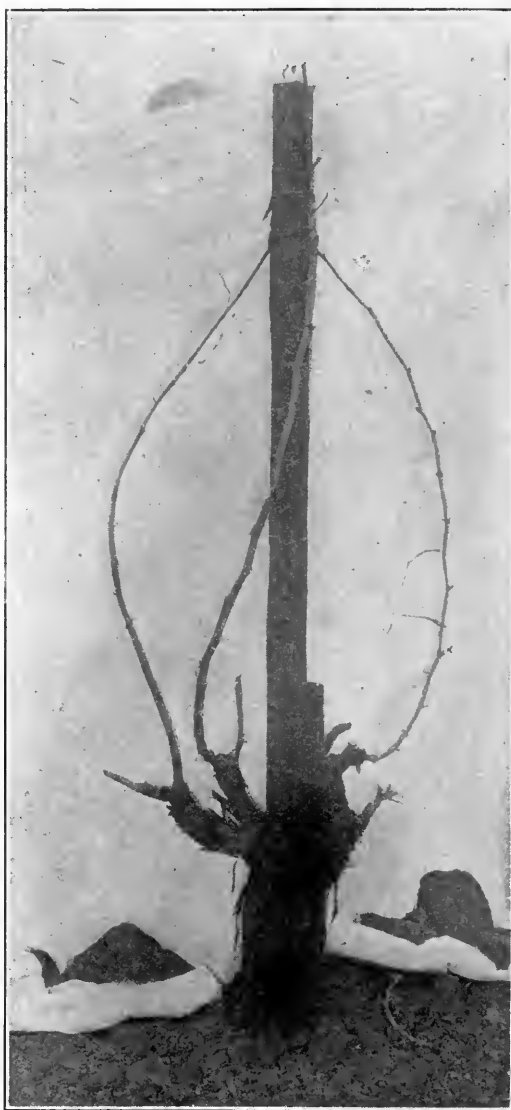


Fig. 59.—Vine with vertical canes.

the hands of skillful pruners. The results with Sultanina are very unsatisfactory. Fig. 60 shows a vineyard of this variety.

By this method, on most of the vines, the fruit canes start from high up near the middle of the stake, and are therefore too short for the best results. The canes which start from low down are in most cases suckers, and therefore of little value for fruit bearing.

Fig. 23 B shows a vine with bowed canes. The method of pruning is exactly the same as in the method just described. The bowing of the canes, however, overcomes some of the defects of that method. It is used regularly in many wine-grape vineyards of the cooler regions. It is unsuited for very vigorous vines in rich soil.

Vertical Cordons.—In head pruning the treatment of young vines up to the second or third winter pruning is identical for all systems.



Fig. 60.—Vineyard with vertical fruit canes. Pruning defective.

In cordon pruning the treatment for the first and second prunings is also the same. That is, the vine is cut back to two buds near the level of the ground until a cane sufficiently long to serve for the formation of the trunk is obtained.

In the vertical cordon the trunk is three to four feet long, instead of one to two, as in head pruning. This makes it necessary to have a longer and more vigorous cane to start with. It may require a year longer to obtain this. That is to say, at the end of the second season's growth many vines will not have a single cane sufficiently developed to give the necessary three and one-half feet of well ripened wood and properly developed buds. At the second winter pruning, therefore, it will often be necessary to cut the vine back to two buds, as at the first winter pruning.

Finally a cane of the required length will be obtained. The vine is then formed as already described for the second winter pruning of

headed vines, except that the cane is left longer. This cane is then tied to the stake, and at the end of the following year we have a vine like that shown in Fig. 61.



Fig. 61.—Vertical cordon; young vine unpruned.

When such a vine is pruned spurs are left at intervals along the trunk, as shown in Fig. 62. Each of these spurs is a fruit spur and is also the commencement of an arm. The future treatment of these arms is the same as that of the arms in head pruning.

Fig. 63 shows a six-year-old Emperor vineyard pruned in this way. It is in excellent condition, but cannot long be kept so. As the vines

grow older it becomes more and more difficult to obtain satisfactory growth on the lower spurs. Finally, the whole growth of the vine is concentrated at the top and instead of a cordon we simply have an inconveniently high headed vine.

Figs. 64 and 65 show an old Emperor vine before and after pruning. It was started as a vertical cordon, but has finally developed into the

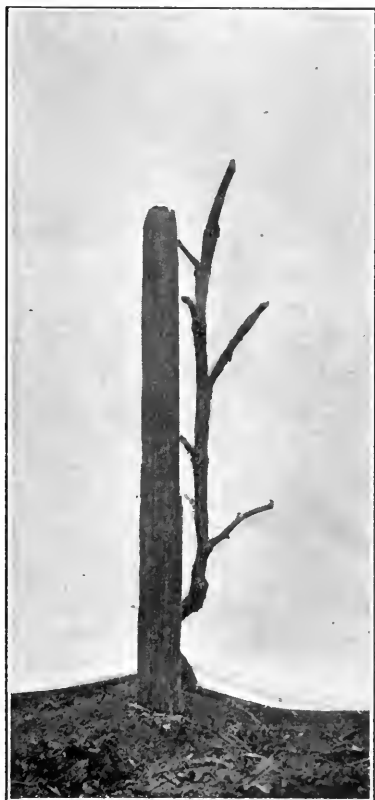


Fig. 62.—Vertical cordon, young vine pruned.

form described. Such a vine has none of the advantages of a cordon and is inferior to a headed vine of moderate height.

Fig. 66 shows a double vertical cordon. This has no advantage over the single cordon and all its disadvantages. It is, moreover, more troublesome and costly to prune and the bunches are more difficult to gather without injury. More than two stems are sometimes grown, which increases these difficulties and defects.

Horizontal Cordons.—During the first two or three years vines which are to be given the form of horizontal cordons are treated ex-



Fig. 63.—Vineyard of vertical cordons.



Figs. 64 and 65.—Ultimate form of a vertical cordon, pruned and unpruned, defective.

actly as for vertical cordons; that is, they are pruned back to two buds each winter and the growth forced by disbudding into a single cane during the summer.

As soon as a well ripened cane of the required length is obtained it is tied to a wire stretched horizontally along the row at from twenty to twenty-four inches from the ground.

For this system of pruning the rows should be twelve to fifteen feet apart and the vines six, seven, or eight feet apart in the rows. As the cordon or trunk of each vine should reach the next vine it will have to be six to eight feet long. The best shape is obtained when the trunk is all formed one year from a single cane (see Fig. 67*a*). It is easier and sometimes necessary, however, to take two years for the formation of the trunk (see Fig. 67*b*). In any case, the cane first tied down should reach at least half way to the next vine. The following year a new cane from the end of this should be used to complete the full length of the trunk.

In attaching the cane to the wire it must be bent over in a gentle curve and care taken not to break or injure it. The proper form of the bend is shown in Figs. 67 and 68 and by the vine at the left side of Fig. 69. Sharp bends such as those shown by the vines in Fig. 70 and on the right of Fig. 69 should be avoided.

The cane should be placed on top of the wire, but should not be twisted around it. The end should be tied firmly and the rest of the cane supported by strings tied loosely in order to avoid girdling when the cane grows.

In the following spring most of the buds on a good cane will start. If the cane is short jointed some of the shoots should be removed and only those shoots allowed to develop which are conveniently situated for permanent arms. If the vines are to be short pruned, the arms should be developed every eight to twelve inches from a few inches beyond the bend to the extreme end. For long pruning the arms should be farther apart, twelve to twenty inches. Shoots starting from the upper side of the cane and growing vertically upward are to be preferred. Shoots starting from the lower side should be rubbed off as soon as they start. As the shoots develop the strongest should be pinched, repeatedly if necessary. This will tend to force the growth of the weaker shoots and to equalize the vigor of all.

As the shoots become long enough they should be tied to the top wire. This will insure their retaining their position on the upper side of the cordon. Most of these shoots will bear grapes, and if they are not tied to the wire the weight of the grapes will bend them towards the ground and turn the cane over. The result will be that the next

year the canes will be all on the under side of the cordon and the cordon will be completely bare on top.



Fig. 66.—Vertical cordon with double trunk, defective.

Such a cordon will always be defective. The arms grow towards the ground and bring the grapes too low and in contact with the soil. The bare top of the cordon will be exposed to the sun, which will weaken it and render it subject to fungous decay. This is what has happened to the defective cordons shown in Figs. 70 and 71.

At the end of the season the vines should have produced a fair crop and there should be from five to ten canes growing on each cordon of full length. These canes are then pruned back to two or three buds, or a little longer for long-pruned varieties.

There is still danger of the turning over of the cordon during the following season. This must be provided for by tying some of the spurs to the upper wire. One at the end, one near the middle, and

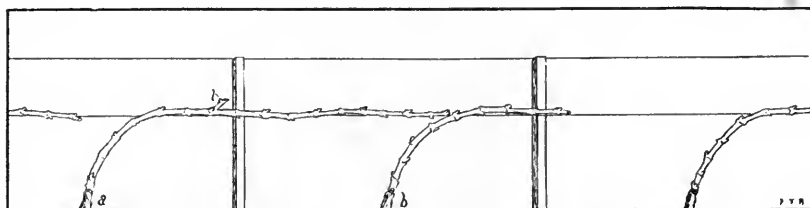


Fig. 67.—Forming the cordon. Second winter pruning.

one near the bend are sufficient. In cases where short spurs are used three of them must be left long enough to reach the wire and the extra buds cut off either at the winter pruning or when they start in the spring. In subsequent years the cordon will be heavy and rigid enough to be safe from turning over.

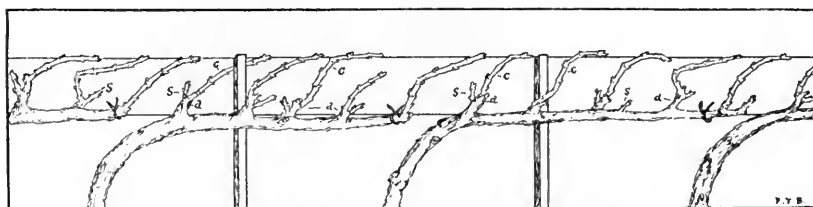


Fig. 68.—Completed cordon (unilateral). Half-long pruning.

During the following spring and summer the vines should be carefully suckered and unnecessary water sprouts removed. Any shoots coming from the lower side of the cordon should be removed early to strengthen the growth in the shoots on the upper side. Neglect of this precaution is shown by the vines in Figs. 70 and 71. Such vines are apt to become dry or decayed on the upper side. At the end of this year, which should be the fourth or fifth from planting at the latest, the cordon will be fully formed and the final style of pruning can be applied. A short-pruned cordon vine is shown in Fig. 26. The arms and spurs are a little too numerous and too close together. If this

vine required the number of buds shown it would have been better to have left the fruit spurs longer and to have left fewer and shorter wood spurs.

Fig. 68 shows a cordon pruned half long. This is an excellent system for Malaga, Emperor, and Corniehon when growing in very fertile soil. It gives the half-long fruit canes which these varieties need to produce good crops.

Fig. 69 shows a well formed cordon in full bearing. The vine is



Fig. 69.—Unilateral horizontal cordon; var. Semillon.

Semillon grafted on St. George and is pruned short. The Semillon is a variety which usually requires long pruning, but the combined effects of grafting on resistant stock and horizontal cordon pruning have increased its fertility so that a sufficient crop is obtained from short spurs. If such a vine were pruned long it would quickly exhaust itself, except in the richest soil.

Fig. 70 shows an old Semillon cordon with several defects. The bend is too short and the growth of cane is all from the lower side. The half-long canes in this case will not exhaust the vine because most of them are water sprout canes and will bear little.

Fig. 71 gives a view of the vineyard in which the vine of Fig. 70 grew. Little or no benefit is obtained from cordons handled in this way.

Fig. 72 shows a vineyard of Colombar, illustrating a bilateral cordon. With vines at the same distance apart, each cordon is only half the length of a unilateral cordon. It is a little easier to establish but more difficult to keep in good form. One branch tends to become stronger than the other and in windy situations the branch growing toward the prevailing wind is more subject to injury.

Renovation of Imperfect or Misshapen Vines.—The pruner with definite ideas who properly handles his vines from the beginning can, in most cases, bring them into the required shape with comparative

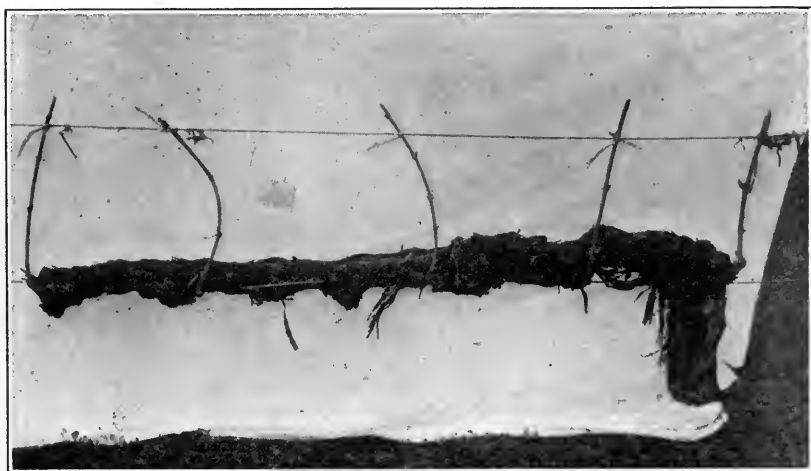


Fig. 70.—Defective cordon.

ease. Often, perhaps usually, he has to deal with vines which have some more or less serious fault. They may be misshapen owing to defective pruning, or otherwise imperfect, owing to mechanical injuries, or as the result of frost, fungi, or insect pests.

If the vines are young, the defects can often be overcome and the vine given a proper form very easily.

Fig. 73 shows a vine at the end of the year after tying up. Most of the growth has gone into a cane near the base and the growth from the top buds has been poor. This condition is likely to occur when a small or imperfectly ripened cane has been used from which to attempt to form a trunk. There are three possible ways of pruning this vine. First, the two small canes at the top may be cut back to form spurs and all other canes removed. This will give a vine with the head at the right height, but all the best wood has been cut off. It will result in four large wounds on the trunk, and the vine will require a

great deal of attention during the following growing season, as water sprouts will be numerous and vigorous on the lower and healthier portion of the vine. Moreover, the attempt to force the growth into the weak top will delay the development of the vine and even result in a permanently weak top.

Second, two or three of the canes about the middle of the trunk may be cut back to spurs and the rest removed, including the whole



Fig. 71.—Defective cordons.

top and the largest cane at the bottom. This will give a healthier and stronger vine, but the head will be too low.

Third, a new trunk may be started from the strong cane near the bottom and the whole growth above removed, as shown in Fig. 74. This preserves the strongest cane, on which most of the energies of the vine were expended during the preceding season, only one large wound is made, and all the defective and dwarfed parts of the vine are removed. The formation of the head is deferred one year, but the vine will have a stronger, healthier, and better formed trunk, and will probably bear as much the following year as if pruned in either of the other ways.

In any vineyard many of the vines, in some, most of them, will show imperfections or abnormalities of a similar nature. No general rule of treatment can be given; each vine is a separate problem. The

pruner should endeavor to choose that method in each case which will finally and most quickly give him a vine of the desired form while utilizing as much as practicable the best and most vigorous parts of the vine and making as few and as small wounds as possible.

As the vines become older it becomes increasingly difficult to overcome defects of formation. The disadvantage of a low head may be in part avoided by gradually lengthening the arms and giving them a more vertical direction. An ill-formed head may be improved by removing badly placed arms and developing new arms where needed.

The trunks of many old vines are so defective that little improve-



Fig. 72.—Vineyard of horizontal cordons, bilateral.

ment can be obtained by these means. It is possible and occasionally profitably to completely renew the trunks of such vines. This can be done by developing a new trunk from a strong cane originating at or below the surface of the ground and then cutting away the old trunk.

This method has the same defect as the grafting of old vines. It leaves a large wound where the old stump was removed, a wound which can never heal and which finally allows the entrance of wood-rot fungi. Such renewed vines, however, may last as long as if the old decayed trunk had been left or longer. They will also be more fruitful and easier to handle properly. The change can be made without the loss of a crop that occurs in grafting. If the stumps are large, the expense of sawing them off is considerable.

Choice of a System.—In choosing a system we must consider carefully the characteristics of the particular variety we are growing. A variety which bears only on the upper buds must be pruned “long,” that is, must be given fruit canes. It should be noted that many varieties, such as Petite Sirah, which will bear with short pruning when grafted on resistant roots, require fruit canes when growing on their own roots. In general, grafted vines require shorter pruning than

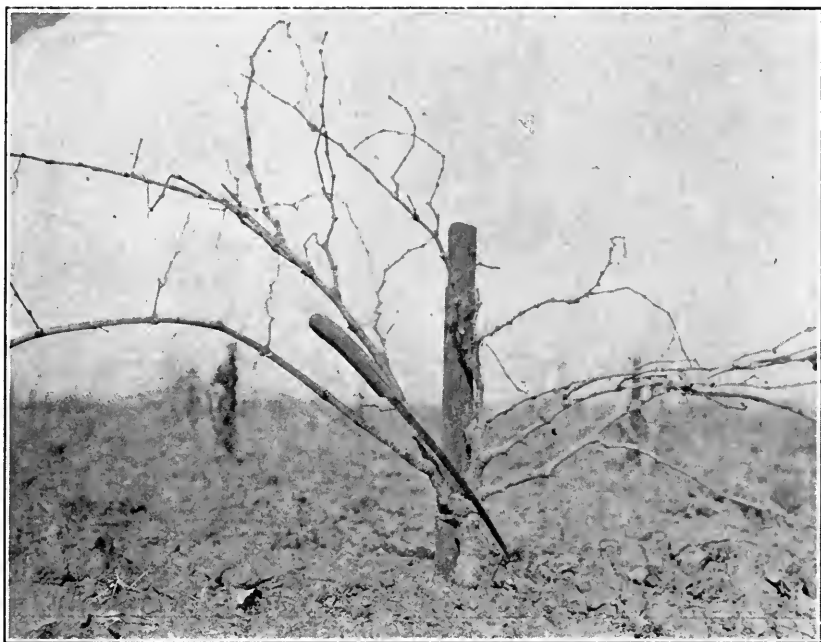


Fig. 73.—Young vine with imperfect top.

ungrafted. If pruned the same, the grafted vines may overbear and quickly exhaust themselves. This seems to be the principal reason for the frequent failure of Muscat vines grafted on resistant stock. The cultural conditions also affect the vine in this respect. Vines made vigorous by rich soil, abundant moisture, and thorough cultivation require longer pruning than weaker vines of the same variety.

The normal size of the bunch is also of importance. This size will vary from one-quarter of a pound to two or three pounds. It is difficult to obtain a full crop from a variety whose bunches are very small, without the use of fruit canes. Spurs will not furnish enough fruit buds without crowding them inconveniently. On the other hand, some shipping grapes may bear larger crops when pruned long, but the bunches and berries may be too small for the best quality.

The possibilities of development vary much with different varieties. A Mission or Flame Tokay may be made to cover a quarter of an acre and develop a trunk four or five feet in circumference. A Zinfandel vine under the same conditions would not reach a tenth of this size in the same time. Vines in a rich valley soil will grow much larger than on a poor hillside. The size and shape of the trunk must be modified accordingly and adapted to the available room or number of vines to the acre.

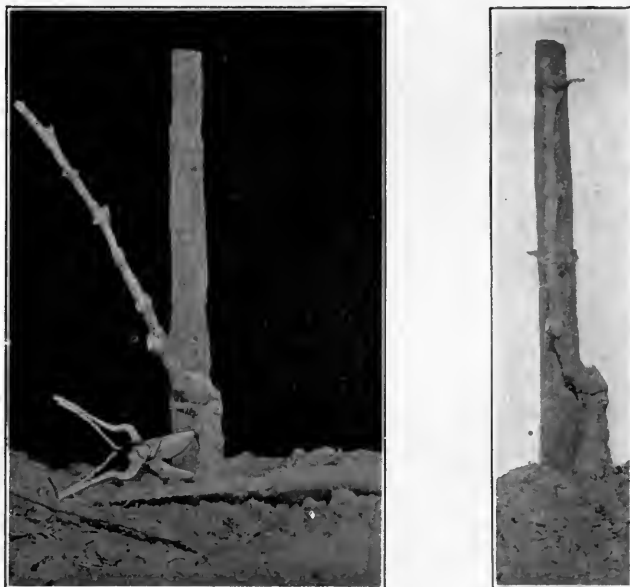


Fig. 74.—Pruning to renew imperfect top of vine of Fig. 73.

The shape of the vine must be such as to protect it as much as possible from various unfavorable conditions. A variety susceptible to oidium, like the Carignane, must be pruned so that the fruit and foliage are not unduly massed together. Free exposure to light and air are a great protection in this respect. The same is true for varieties like the Muscat, which have a tendency to "coulure" if the blossoms are too moist or shaded. In frosty locations a high trunk will be a protection, as the air is always colder close to the ground.

The qualities required in the crop also influence our choice of a pruning system. With wine grapes, even, perfect ripening and full flavor are desirable. These are obtained best by having the grapes at a uniform height from the ground and as near to it as possible. The

same qualities are desirable in raisin grapes, with the addition of large size of the berries. With shipping grapes the size and perfection of the berries and bunches are the most essential characteristics. The vine, therefore, should be so formed that each bunch hangs clear, free from injurious contact with canes or soil and equally exposed to light and air.

The maximum returns in crop depend on the early bearing of young vines, the regularity of bearing of mature vines, and the longevity of the vineyard. These are insured by careful attention to all the details of pruning, but are possible only when the vines are given a suitable form.

The running expenses of a vineyard depend in a great measure on the style of pruning adopted. Vines of suitable form are cultivated, pruned, and the crop gathered easily and cheaply. This depends also both on the form of vine adopted and on care in details.

It is impossible, therefore, to state for any particular variety or any particular location the best style of pruning to be adopted. All that can be done is to give the general characteristics of the variety and to indicate how these may be modified by grafting, soil, or climatic or other conditions.

The most important characteristic of the variety in making a choice of a pruning system is whether it normally or usually requires long or half-long pruning. With this idea, the principal grapes grown in California, together with all those grown at the Experiment Station on which data exist, have been divided into five groups in the following list:

1. *Varieties Which Require Long Pruning Under All Conditions.*—Clairette blanche, Corinth white and black, Seedless Sultana, Sultanina white (Thompson's Seedless) and rose.

2. *Varieties Which Usually Require Long Pruning.*—Bastardo, Boal de Madeira, Chardonay, Chauché gris and noir, Colombar, Crabbe's Black Burgundy, Dizmar, Gamais, Kleinberger, Luglienga, Marsanne, Marzemino, Merlot, Meunier, Muscadelle de Bordelais, Nebbiolo, Pagadebito, Peverella, Pinots, Rieslings, Rish Baba, Robin noir, Ruländer, Sauvignon blanc, Semillon, Serine, Petite Sirah, Slancamenca, Steinschiller, Tinta Cao, Tinta Madeira, Trousseau, Verdelho, Petit Verdot, Wälchriesling.

3. *Varieties Which Usually Require Short Pruning.*—Aleatico, Aligoté, Aspiran, Bakator, Bouschets, Blaue Elbe, Beba, Bonarda, Barbarossa, Catarattu, Charbono, Chasselas, Durif, Freisa, Frontignan, Furmint, Grand noir, Grosseblau, Green Hungarian, Malmsey,

Mantuo, Monica, Mission, Moscatello fino, Mourisco branco, Mourisco preto, Negro amaro, Palomino, Pedro Zumbon, Perruno, Pizzutello di Roma, Black Prince, West's White Prolific, Quagliano, Rodites, Rozaki, Tinta Amarella, Vernaccia bianca, Vernaccia Sarda.

4. *Varieties Which Require Short Pruning Under All Conditions.*—Aramon, Burger, Black Morocco, Mourastel, Muscat of Alexander, Napoleon, Piepoule blanc and noir, Flame Tokay, Ugni blanc, Verdal, Zinfandel.

5. *Varieties of Table Grapes Which Usually Require Half-Long or Cordon Pruning.*—Almeria (Ohanez), Bellino, Bermestia bianca and violacea, Cipro nero, Dattier de Beirut, Cornichon, Emperor, Black Ferrara, Malaga, Olivette de Cadenet, Pis-de-Chevre blanc, Schiradzouli, Zabalkanski.

These lists must not be taken as indicating absolutely for all cases how these varieties are to be pruned. They simply indicate their natural tendencies. Certain methods and conditions tend to make vines more fruitful. Where these occur shorter pruning than is indicated may be advisable. On the other hand, other methods and conditions tend to make the vines vigorous at the expense of fruitfulness. Where these occur longer pruning may be advisable.

The more usual factors which tend toward *fruitfulness* are:

Grafting on resistant vines, especially on certain varieties such as those of Riparia and Berlandieri;

Old age of the vines;

Mechanical or other injuries to any part of the vine;

Large development of the trunk, as in the cordon systems.

The more usual factors which tend toward *vigor* at the expense of fruitfulness are:

Rich soil, especially large amounts of humus and nitrogen;

Youth of the vines;

Excessive irrigation or rainfall (within limits).

In deciding what system of pruning to adopt, all these factors, together with the nature of the vine and the uses to which the fruit is to be put, must be considered. It is best when the vineyard is started to err on the side of short pruning. While this may diminish slightly the first one or two crops, the vines will gain in vigor and the loss will be made up in subsequent crops. If the style of pruning adopted results in excessive vigor of the vines, it should be gradually changed in the direction of longer pruning with the object of utilizing this vigor in the production of crop.

This change should be gradual, or the risk is run of injuring the vitality of the vines by one or two excessively heavy crops. Finally, each year the condition of the individual vine should determine the kind of pruning to be adopted. If the vine appears weak, from whatever cause, it should be pruned shorter or given less spurs or fruit canes than the year before. On the contrary, if it appears unnecessarily vigorous, more or longer spurs or fruit canes should be left. Every vine should be judged by itself. It is not possible to give more than general directions for the pruning of the whole vineyard. It cannot be well pruned unless the men who do the actual pruning understand their work and are capable of using sufficient judgment to properly modify their methods for each individual vine.

STATION PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION

BULLETINS

- No.
185. Report of Progress in Cereal Investigations.
251. Utilization of the Nitrogen and Organic Matter in Septic and Imhoff Tank Sludges.
253. Irrigation and Soil Conditions in the Sierra Nevada Foothills, California.
261. Melaxuma of the Walnut, "Juglans regia."
262. Citrus Diseases of Florida and Cuba Compared with Those of California.
263. Size Grades for Ripe Olives.
266. A Spotting of Citrus Fruits Due to the Action of Oil Liberated from the Rind.
267. Experiments with Stocks for Citrus.
268. Growing and Grafting Olive Seedlings.
270. A Comparison of Annual Cropping, Biennial Cropping, and Green Manures on the Yield of Wheat.
271. Feeding Dairy Calves in California.
272. Commercial Fertilizers.
273. Preliminary Report on Kearney Vineyard Experimental Drain.
274. The Common Honey Bee as an Agent in Prune Pollination.
275. The Cultivation of Belladonna in California.
276. The Pomegranate.
278. Grain Sorghums.
279. Irrigation of Rice in California.
280. Irrigation of Alfalfa in the Sacramento Valley.
282. Trials with California Silage Crops for Dairy Cows.
283. The Olive Insects of California.
285. The Milch Goat in California.
286. Commercial Fertilizers.
288. Potash from Tule and the Fertilizer Value of Certain Marsh Plants.

- No.
290. The June Drop of Washington Navel Oranges.
299. The Use of Lumber on California Farms.
300. Commercial Fertilizers.
301. California State Dairy Cow Competition, 1916-18.
302. Control of Ground Squirrels by the Fumigation Method.
303. Grape Syrup.
304. A Study on the Effects of Freezes on Citrus in California.
308. I. Fumigation with Liquid Hydrocyanic Acid. II. Physical and Chemical Properties of Liquid Hydrocyanic Acid.
309. I. The Carob in California. II. Nutritive Value of the Carob Bean.
310. Plum Pollination.
311. Investigations with Milking Machines.
312. Mariout Barley.
313. Pruning Young Deciduous Fruit Trees.
316. The Kaki or Oriental Persimmon.
317. Selections of Stocks in Citrus Propagation.
318. The Effects of Alkali on Citrus Trees.
319. Capriffs and Caprification.
320. Control of the Coyote in California.
321. Commercial Production of Grape Syrup.
322. The Evaporation of Grapes.
323. Heavy vs. Light Grain Feeding for Dairy Cows.
324. Storage of Perishable Fruit at Freezing Temperatures.
325. Rice Irrigation Measurements and Experiments in Sacramento Valley, 1914-1919.
326. Brown Rot of Apricots.
327. Commercial Fertilizers.

CIRCULARS

- No.
70. Observations on the Status of Corn Growing in California.
76. Hot Room Callusing.
82. The Common Ground Squirrels of California.
113. Correspondence Courses in Agriculture.
114. Increasing the Duty of Water.
115. Grafting Vinifera Vineyards.
126. Spraying for the Grape Leaf Hopper.
127. House Fumigation.
128. Insecticide Formulas.
129. The Control of Citrus Insects.
130. Cabbage Growing in California.
131. Spraying for Control of Walnut Aphids.
135. Official Tests of Dairy Cows.
137. Wood Decay in Orchard Trees.
138. The Silo in California Agriculture.
139. The Generation of Hydrocyanic Acid Gas in Fumigation by Portable Machines.
143. Control of Grasshoppers in Imperial Valley.
144. Oidium or Powdery Mildew of the Vine.
148. "Lungworms".
152. Some Observations on the Bulk Handling of Grain in California.
153. Announcement of the California State Dairy Cow Competition, 1916-18.
154. Irrigation Practice in Growing Small Fruits in California.
155. Bovine Tuberculosis.
156. How to Operate an Incubator.
157. Control of the Pear Scab.
158. Home and Farm Canning.
159. Agriculture in the Imperial Valley.
160. Lettuce Growing in California.
164. Small Fruit Culture in California.

- No.
165. Fundamentals of Sugar Beet Culture under California Conditions.
167. Feeding Stuffs of Minor Importance.
168. Spraying for the Control of Wild Morning-Glory within the Fog Belt.
169. The 1918 Grain Crop.
170. Fertilizing California Soils for the 1918 Crop.
172. Wheat Culture.
173. The Construction of the Wood-Hoop Silo.
174. Farm Drainage Methods.
175. Progress Report on the Marketing and Distribution of Milk.
176. Hog Cholera Prevention and the Serum Treatment.
177. Grain Sorghums.
178. The Packing of Apples in California.
179. Factors of Importance in Producing Milk of Low Bacterial Count.
181. Control of the California Ground Squirrel.
182. Extending the Area of Irrigated Wheat in California for 1918.
183. Infectious Abortion in Cows.
184. A Flock of Sheep on the Farm.
185. Beekeeping for the Fruit-grower and Small Rancher or Amateur.
188. Lambing Sheds.
189. Winter Forage Crops.
190. Agriculture Clubs in California.
191. Pruning the Seedless Grapes.
193. A Study of Farm Labor in California.
198. Syrup from Sweet Sorghum.
201. Helpful Hints to Hog Raisers.
202. County Organization for Rural Fire Control.

CIRCULARS—Continued

No.

- 203. Peat as a Manure Substitute.
- 205. Blackleg.
- 206. Jack Cheese.
- 207. Neufchatel Cheese.
- 208. Summary of the Annual Reports of the Farm Advisors of California.
- 210. Suggestions to the Settler in California.
- 214. Seed Treatment for the Prevention of Cereal Smuts.
- 215. Feeding Dairy Cows in California.
- 217. Methods for Marketing Vegetables in California.
- 218. Advanced Registry Testing of Dairy Cows.

No.

- 219. The Present Status of Alkali.
- 220. Unfermented Fruit Juices.
- 221. How California is Helping People Own Farms and Rural Homes.
- 222. Fundamental Principles of Co-operation in Agriculture.
- 223. The Pear Thrips.
- 224. Control of the Brown Apricot Scale and the Italian Pear Scale on Deciduous Fruit Trees.
- 225. Propagation of Vinea.
- 226. Protection of Vineyards from Phylloxera.